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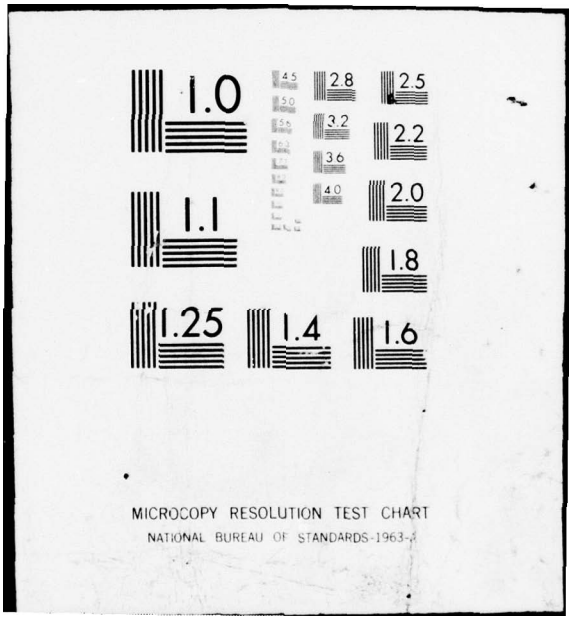
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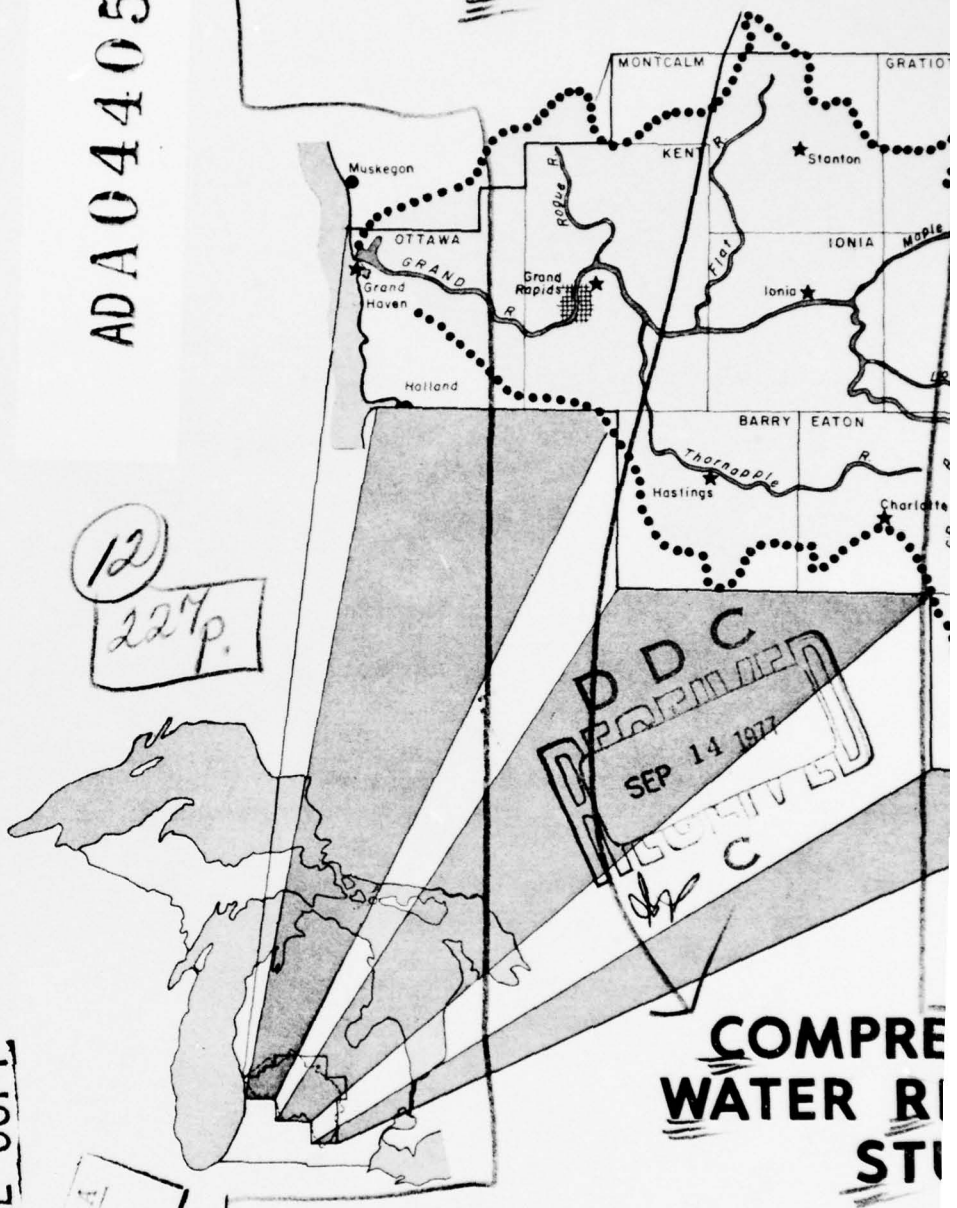
GRAND RIVER BASIN

MICHIGAN



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APPENDIX M - AGRICULTURE

UNITED STATES DEPARTMENT OF AGRICUL
ECONOMIC RESEARCH SERVICE · FOREST S
SOIL CONSERVATION SERVICE

In Cooperation with: The Grand River Basin Coordinating Co
Chairmanship: U.S. Army Engineer District, Detroit

(11) May, 1970

COMPREHENSIVE WATER RESOURCES STUDY OF THE GRAND RIVER BASIN, MICHIGAN

APPENDIX M

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COMPREHENSIVE WATER RESOURCES STUDY

GRAND RIVER BASIN

MICHIGAN

SUMMARY

This report presents a plan for the future development of agricultural water and related land resources and the potential for solving other water problems and meeting projected needs through programs and projects in the Grand River Basin. This Basin, located in lower Michigan, consists of approximately 5,560 square miles or 9.8% of the State. The Grand River outlets into Lake Michigan as part of the Great Lakes and St. Lawrence Drainage Basin.

More than one-half of the area is cropland while forest land and pasture comprise nearly one-sixth and one-twelfth of the Basin, respectively. The remaining acreage is in water areas, miscellaneous, and urban uses.

Dairy, livestock, and general farming are the dominant types of agriculture, with specialized poultry, fruit, and vegetable production in the western fringe. There are a large number of part-time and residential farms, particularly near the urban centers of Grand Rapids, Jackson, and Lansing.

Total available cropland for agricultural use is expected to decrease because of urban and related nonfarm uses. Sufficient cropland remains, however, to meet projected demands for food and fiber unless large, unanticipated non-farm uses materialize. Sales of livestock and livestock products will continue to provide the major source of on farm income to Basin farmers. Total farm income expressed in constant value terms, is projected to 316 million dollars by the year 2020, more than double the current amount.

Rural farm population is expected to decline by four-fifths over the study period, while total labor requirements only decrease by one-third. Employment in the forest industry (currently about 2,500) is expected to increase by nearly 150 percent, mainly in the manufacture of primary timber products.

A land treatment program which will provide for continuous utilization of land resources to satisfy current needs and, at the same time, conserve this resource for future needs is vital. A program of land treatment measures to reduce runoff, erosion, and sediment should be carried out. Such a program has been anticipated and the projected agricultural production and land requirements are based upon it. This land treatment program would include sound conservation measures designed to protect and improve agricultural and forest lands and to increase overall farming efficiency. All well managed lands will help control water runoff, provide conditions necessary for recharging underground water supplies, and help improve the quality of streams, and water supplies.

A technical assistance program for urban and built-up areas will help protect soil and water resources, and provide an opportunity for man to live in harmony with his natural environment. Assistance will be provided in land use planning designed to reduce soil erosion, help maintain water quality, reduce flood damages, improve vegetative cover, and enhance natural beauty.

Although sufficient cropland to meet production requirements is available, after 1980 more production will occur on less productive soils. These soils are better suited to forest and pasture production; consequently, agricultural resource development through flood protection, irrigation, and drainage may provide for a more efficient means of production. Flood damage to existing cropland in upstream watersheds does not present a major problem to agriculture; however, flood damages are significant in specific sub-basins. An economic potential for the irrigation of fruits, vegetables, and potatoes, exists and is expected to expand considerably in the future. The economic potential for cropland drainage far exceeds that for irrigation, particularly where general field crops are concerned.

Ground and surface water supplies are in excess of agricultural needs, but distribution of water supplies with respect to time and place of need will remain a problem in a few localized areas.

There are 14 potential upstream watershed areas identified, which have potential for development in the next 10 to 15 years. These

developments will alleviate flooding and/or inadequate drainage on about 71,400 acres, providing average annual benefits of 2.7 million dollars. Included are structural measures for flood prevention, recreation, drainage, and fish and wildlife.

There are 26 additional upstream watershed areas which are economically justified for future development. They would be justified primarily through bringing new land into agricultural production, and may become feasible with a growing demand for food and fiber in the future.

SECTION I
INTRODUCTION

1. SCOPE

This report by the United States Department of Agriculture (USDA) is part of a Type II comprehensive study for the water and related-land resources in the Grand River Basin in Michigan. Additional studies and reports made by other Federal and State agencies will be utilized with this study in preparing a comprehensive plan of development for the Basin.

This report appraises overall problems and needs of water and related-land resources and the potentials for development.

Intensive investigations were made to determine the existing resources and the extent of their present use. Information was obtained through personal contact, literature search, and on-site observation. Future resource needs were correlated with projected economic requirements of the population and anticipated land use changes. Resource development potentials were correlated with available resources and their future needs by the Basin population.

2. NEED OF STUDY

The Comprehensive Water Resources Study will be instrumental in helping the people of the Basin meet their future water and land use needs. This Appendix will provide a plan of action for the orderly development of the agricultural water and related land resources. By completing the programs and projects described herein by the established target dates, the people can more effectively meet the projected Basin resource needs in the year 2020. By developing the natural resources as sustaining producers, the Basin will be better able to serve its people in the following centuries.

3. AREA OF STUDY

The Grand River Basin, located in lower Michigan, has 5,560 square miles of drainage in parts of 20 counties. The Grand River and its tributaries within the Basin begin in the south and southcentral parts of the State and outlet into Lake Michigan at Grand Haven. Grand Rapids, Lansing, and Jackson are the largest cities. The Basin occupies 9.8 percent of the State's area and in 1960 the 11 major counties had

14 percent of the State's population. Crop, forested and pasture lands, and water areas occupy over three-fourths of the Basin area.

4. OBJECTIVES

The objectives of this study were to: (1) determine the extent and location of present agricultural and forest resources, problems and resource development needs, (2) project a pattern of land use for agriculture and forestry to meet these needs, recognizing the competing uses for land, in the target years 1980, 2000 and 2020, (3) determine future water requirements for agriculture and forestry, (4) evaluate the feasibility of works of improvement for upstream watershed protection, flood prevention, and agricultural water management, (5) locate suitable structure sites and evaluate their potential for flood prevention, and inventory their possibilities for other beneficial water storage, and (6) evaluate the economic impact on proposed developments and those resulting from projected 1980, 2000, and 2020 agricultural land and forest use changes.

5. PARTICIPANTS

The USDA agencies participating in the study are the Economic Research Service, Forest Service, and Soil Conservation Service. Assistance has been received from local, State, and other Federal agencies. The leadership for this USDA study has been assigned to the Soil Conservation Service.

6. AUTHORITY

The USDA participates in this study under authority contained in Section 6 of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, as amended).

The Grand River Basin lies entirely within the Great Lakes Basin. This latter basin is the subject of a Type I comprehensive study which is a broader and less intensive investigation than a Type II study. Normally, Type I studies are completed before Type II studies; however, authorization for investigation funds of the Grand River occurred substantially ahead of authorization for the Great Lakes Study.

7. VALUE OF STUDY

Findings in this study can be used most effectively by local gov-

ernment officials, i.e., planning commissioners, county supervisors and city officials, to develop projects for the improvement and development of the agricultural water and related land resources in their particular areas. The information will be useful to state and Federal government agencies in allowing them to coordinate their assistance programs with locally based projects. By having the existing economic conditions and the future problems, needs, and economic development potential spelled out, a uniformity of action can be achieved with a minimal duplication of cost, time, and results.

SECTION II
NATURAL RESOURCES OF THE BASIN

1. LOCATION AND SIZE

The study area, located in lower Michigan, consists of approximately 3,558,440 acres (5,560 square miles) of relatively level to gently rolling land. This land includes all of 2 counties and portions of 18 other counties (Table 1, Page 5). The area was divided into 11 subbasins or major tributaries (Table 2, Page 6, and Plate 1, Addendum). The Grand River is the main drainage channel of the Basin, rising in south central Michigan in Hillsdale County, meandering first north, then west from Lansing, and outletting into Lake Michigan at Grand Haven, as part of the Great Lakes and St. Lawrence drainage Basin.

2. CLIMATE

The climate varies from modified marine (Great Lakes influence) to continental, and also shows a variation from the western to the eastern portion. Lake Michigan affects the western portion thereby reducing extremes in temperature in both winter and summer. This modified climate has contributed to the development of a "fruit belt" in the counties adjacent to Lake Michigan.

The temperature in the Basin fluctuates over a wide range with a mean annual temperature of 47.8°F. Extremes of -33°F and +109°F have been recorded. The mean temperatures are 23.5°F for January and 72.5°F for July.

TABLE 1 - Area Distribution By County

Grand River Basin, Michigan

County	Basin Area		Basin Area	Percent of County in Basin
	(Acres)	(Square Miles)	(Percent)	
Allegan	3,910	6.1	0.11	0.7
Barry	246,600	385.3	6.93	70.2
Calhoun	1,420	2.2	0.04	0.3
Clinton	366,870	573.2	10.31	100.0
Eaton	281,830	440.4	7.92	77.7
Gratiot	138,780	216.8	3.90	38.3
Hillsdale	4,630	7.2	0.13	1.2
Ingham	348,720	544.9	9.80	97.5
Ionia	368,290	575.5	10.35	100.0
Isabella	360	0.6	0.01	0.1
Jackson	316,700	494.8	8.90	70.2
Kent	540,520	844.6	15.19	98.0
Livingston	79,710	124.5	2.24	21.8
Mecosta	15,300	23.9	0.43	4.2
Montcalm	331,640	518.2	9.32	72.8
Muskegon	77,220	120.7	2.17	23.9
Newaygo	43,410	67.8	1.22	7.9
Ottawa	231,650	362.0	6.51	64.2
Shiawassee	150,880	235.7	4.24	43.7
Washtenaw	9,960	15.6	0.28	2.2
TOTAL	3,558,400	5,560.0	100.00	

TABLE 2 - Area Distribution By Sub-basin

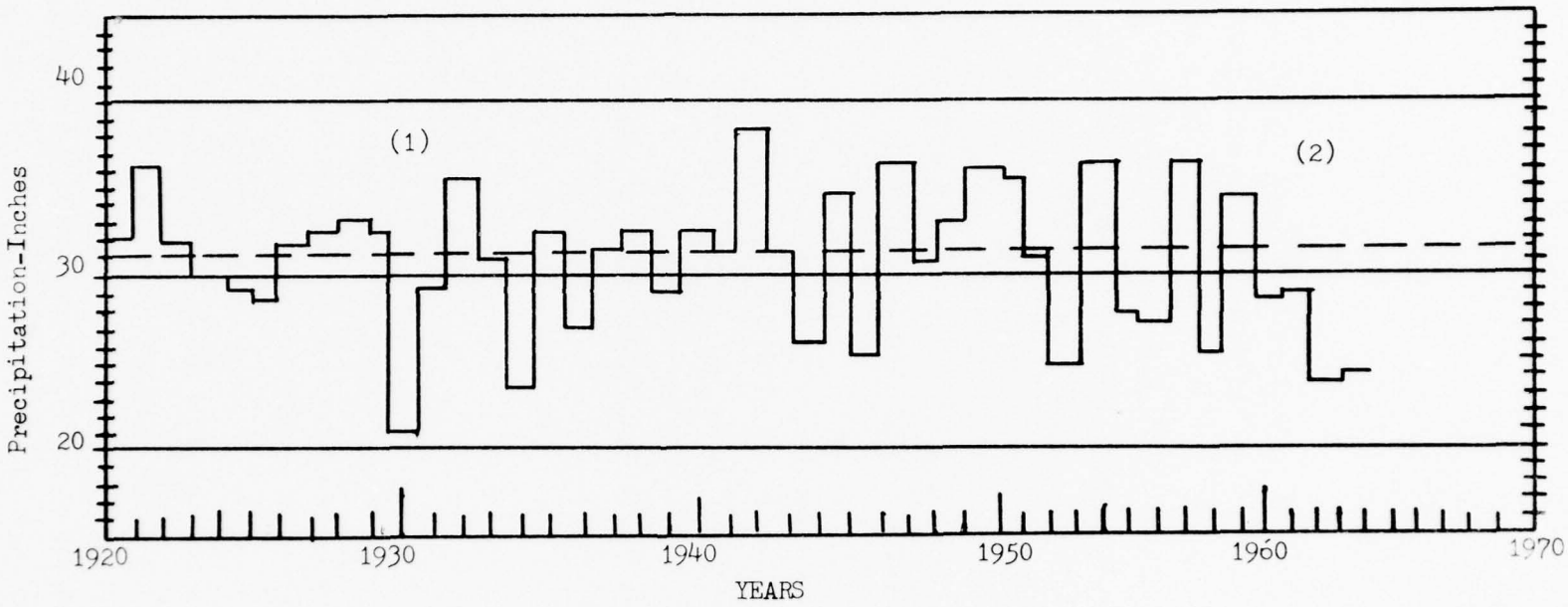
Sub-basin	Sub-basin Area (Acres)	Sub-basin Area (Square Miles)	Sub-basin Area (Percent)
Flat River	359,500	561.7	10.10
Lookingglass River	199,700	312.0	5.61
Lower Grand River	527,700	824.5	14.83
Maple River	496,200	775.3	13.95
Middle Grand River	357,500	558.6	10.05
Portage River	118,900	185.8	3.34
Red Cedar River	296,100	462.7	8.32
Rogue River	163,800	256.0	4.60
Stony Creek	114,000	178.1	3.21
Thornapple River	541,000	845.3	15.20
Upper Grand River	384,000	600.0	10.79
TOTAL	3,558,400	5,560.0	100.00

The average annual precipitation is 31.4 inches (Figure 1, Page 7) but varies from 29.7 to 33.4 inches. Despite variation across the Basin, precipitation is fairly evenly distributed throughout the year, with slightly more rain during the growing season reducing the likelihood of severe drought. Torrential rains in some years have been severe and have resulted in excessive runoff and flash floods during the spring months. Sleet and ice storms occur almost every year. Tornadoes causing extensive damages occur at irregular intervals. But on an overall basis, these extreme conditions occur quite infrequently and are generally quite localized.

Variation in average annual snowfall over the Basin is quite extensive due to the effects of Lake Michigan and the prevailing southwesterly winds. Counties close to the Lake receive the largest amounts. This variation ranges from 35.1 to 60.3 inches. The average annual snowfall for the Basin is 45.2 inches.

Figure 1 - Annual Precipation 1920-1963

Grand River Basin, Michigan



(1) Normal annual Basin precipitation based on U.S. Weather Bureau records located within and near the Basin with at least 50 years of record.

(2) Annual Basin precipitation amounts based on records compiled at most U.S. Weather Bureau stations operating within the Basin during any given year.

U.S. ARMY ENGINEER DISTRICT, DETROIT

Length of growing season ranges from 130 to 180 days with 180 days along Lake Michigan. Low-lying lands, and particularly organic soils, are susceptible to late spring and early fall frosts.

3. PHYSICAL DESCRIPTION

The origin and composition of soil materials and the general rolling topography were influenced by the Wisconsin stage of glaciation which covered the land between ten and twenty thousand years ago.

a. Geology The geology of the Basin includes surface formations of glacial origin that vary from a few feet to several hundred feet in thickness. The glacial materials are underlain by sandstone, shale, and some limestone formations. The topography of the watershed is influenced by a system of terminal moraines, and lake plains from former level of Lakes Michigan and Huron. The elevation difference between the headwater of the Grand River in Hillsdale County and its outlet into Lake Michigan is about 460 feet.

b. Soils Most of the central part of the Basin is covered by medium and moderately-fine textured glacial till. This till is the parent material in which Miami, Conover, Kawkawlin, and Nester soils are developed. Much of the eastern and western parts of the Basin is covered by moderately-coarse and coarse-textured glacial materials. This is the parent material in which the Spinks, Boyer, Oshtemo, McBride, Hillsdale, and Montcalm soils are developed. The Maple River, Stony Creek, and Lookingglass Rivers drain areas that are level to strongly sloping (6 percent plus) with soils that are largely somewhat poorly to poorly drained.

The Red Cedar River, the upper reaches of the Grand River, and the Thornapple River drain areas that are somewhat poorly to well drained. The Flat River, the Rogue River, and the lower reaches of the Grand River drain areas that are largely gently rolling to steep (10 percent plus) sandy soils that are somewhat poorly to well drained.

c. Minerals The Basin's natural resources include fuels and nonmetallic minerals. Petroleum, natural gas, and peat constitute the fuels, while the nonmetallic minerals include sand, gravel, clay, shale, sandstone, gypsum, limestone, marl, and natural salines.

The bulk of the Basin's nonmetallic minerals have construction uses, primarily in highways, residential buildings, and drain tiles. Limestone is crushed for construction and agricultural uses. The primary use of peat is horticultural.

4. LAND RESOURCES

Over 99 percent of the Basin acreage of 3.6 million is land area. Generally fertile soils of glacial parent materials support a variety of row, small grain, hay, and truck crops, as well as sustaining varied livestock enterprises. Forested lands are concentrated in the northern and western parts of the Basin and are composed mostly of hardwood trees.

a. Available land resources In 1958, cropland comprised 54.5 percent of the total Basin area as reported by the Inventory of Soil and Water Conservation Needs (CNI). (Table 3, Page 12). This was nearly one-fifth of all cropland in the State. About 15 percent of the Basin was in forest cover. Pasture land and areas of urban build-up each covered about 8 percent of the Basin. The state-wide percentages of crop and forested land, however, are nearly the reverse of the Basin. In Michigan 29 percent of the land is in crop use and 51 percent is forested.

The National Inventory of Soil and Water Conservation Needs (CNI) is a survey and classification of the land use, conservation, and preservation needs on both publicly and privately-owned lands in this country. Objectives of the inventory were: (1) to develop current, detailed data on land use and conservation treatment needs on non-Federal rural land and (2) to obtain data on watershed project needs on both privately and publicly-owned land.

The actual surveys were made by county on a sample basis which represented two percent of the country's land. Sample areas of 160 acres each were mapped for the average county, then expanded to represent the total country. The county data was then combined into state and national summaries.

The information obtained has been useful in formulating programs, planning conservation work, conducting research, and for other purposes by both governmental agencies and private institutions.

In this inventory cropland was defined to include all land under tillage, in orchards, or held temporarily with a full plant cover in anticipation of future cultivation, such as soil improvement crops, rotation pasture and tame hay. Pasture and range represented land which was less than 10 percent covered by trees and was planted in grass or other long-term forage primarily used for grazing. Rotation pasture was not included. Forested land generally had greater than a 10 percent tree canopy cover. All land in farms not classified in the above categories was included in other agricultural land. Acreage estimates were prepared for federal land, urban-industrial and built-up areas of 10 acres or more, and water areas less than 40 acres in size, but these categories were not inventoried from the standpoint of conservation needs.

b. Land Resource Areas Land Resource Areas (LRA's) are extensive geographic areas having similar physical and climatic characteristics. One or more LRA's make up a Land Resource Region. The 20 such regions in the United States (48 conterminous states) cover broad areas having similar patterns of soils, climate, native vegetation, water resources, topography, and land use. Within each major land resource area are even more-similar conditions of soils, climate, land use, or type of farming. The separation between areas is not so much based on their relationships to agriculture, but on their combinations and intensities of problems in soil and water conservation.

The Basin includes parts of two LRA's, the LRA 98, Southern Michigan Drift Plain, and the LRA 99, Erie-Huron Lake Plain, both of which are a part of the Lake States Fruit, Truck, and Dairy Land Resource Region. Seventeen of twenty counties, lying wholly or partly in the Basin, are in LRA 98. Gratiot, Clinton, and Shiawassee Counties lie partly within the two LRS's. However, since the large majority of the Basin counties are in LRA 98, they are classified in this study as being completely within that LRA. (Plate 1, Addendum).

LRA 98 is located in south central Michigan and extends from the shore of Lake Michigan part way into the "Thumb" area of the State.

Dairy and general farming are the dominant types of agriculture in this LRA with specialized pountry, fruit, and vegetable production in

the western fringe.[1] Truck crops and sod are grown on organic soil dispersed throughout the Basin. The portion of LRA 99 that is in the Basin does not differ significantly from LRA 98 in these respects. There are a large number of part-time and residential farms in the area, particularly near the urban centers of Grand Rapids, Jackson, and Lansing.

c. Soil Associations An inventory of the kinds of soils, including slope and erosion characteristics, is available through the CNI. These soils can be grouped into capability units which combine soil series, soil types, and phases of soil types that are nearly alike in agricultural potential, plant growth, and response to similar treatment and management.

For the analysis of current and potential crop and pasture production, the capability units have been combined into seven broad soil associations. These broad associations were based on the cooperative work between the U.S. Soil Conservation Service and the Michigan Agricultural Experiment Station. Table 4 (Page 14) lists in greater detail the general characteristics of each broad soil association. Table 5 (Page 17) shows their area distribution by county. Plate 2 (Addendum) shows the areal distribution of these associations.

d. Land Use The 1,940,000 acres of cropland in the Basin are used in varying intensities (Table 3, Page 12). Corn, small grain, soybeans, potatoes, cucumbers, and meadow are grown primarily on Soil Associations 2,3,4, and 5 (Table 4, Page 13) and Plate 2, Addendum). Onions, mint, celery, potatoes, truck crops, soubeans, and some corn are concentrated in the organic soil areas. Fruit crops are generally grown in the western portion of the Basin.

Most of the 536,250 acres of forested land are in Kent, Montcalm and Ottawa Counties in the northern and western sections of the Basin (Table 3, Page 12, and Figure 2, Page 13). Hardwoods predominate, with pine and other softwoods covering only a minor part of the area. Oak and lowland hardwood types cover most of the forested land. Small amounts of cottonwood and aspen have limited distribution.

1/ For a discussion of the present agricultural economy of the Basin see: The Agricultural Economy of the Grand River Basin, USDA, Economic Research Service, May 1964.

TABLE 3 - Basin and State Land Use Comparisons - 1958

Grand River Basin, Michigan

	Basin		Michigan		Proportion Basin Area is of State Area
	Area (1,000 Acres)	Proportion of Land Area (Percent)	Area (1,000 Acres)	Proportion of Land Area (Percent)	(Percent)
Cropland	1,940.0	54.5	10,461.2	28.7	18.5
Pasture and range	296.9	8.3	1,764.7	4.8	16.8
Forest	536.2	15.1	18,718.9	51.3	2.9
Other land	478.4	13.4	3,124.5	8.5	15.3
Federal land (non-forest) and Urban built-up	279.7	7.9	2,255.8	6.2	1.2
Water areas 1/	27.2	.8	167.0	0.5	16.2
Total Area	3,558.4	100.0	36,492.1 1/	100.0	9.8

1/ There are 766.1 thousand acres of inland water areas 40 acres and larger in Michigan, which are not counted in these definitions. See Land and Water Area, By Counties, 1960, Bureau of Census, Department of Commerce.

FOREST COVER
GRAND RIVER BASIN–MICHIGAN

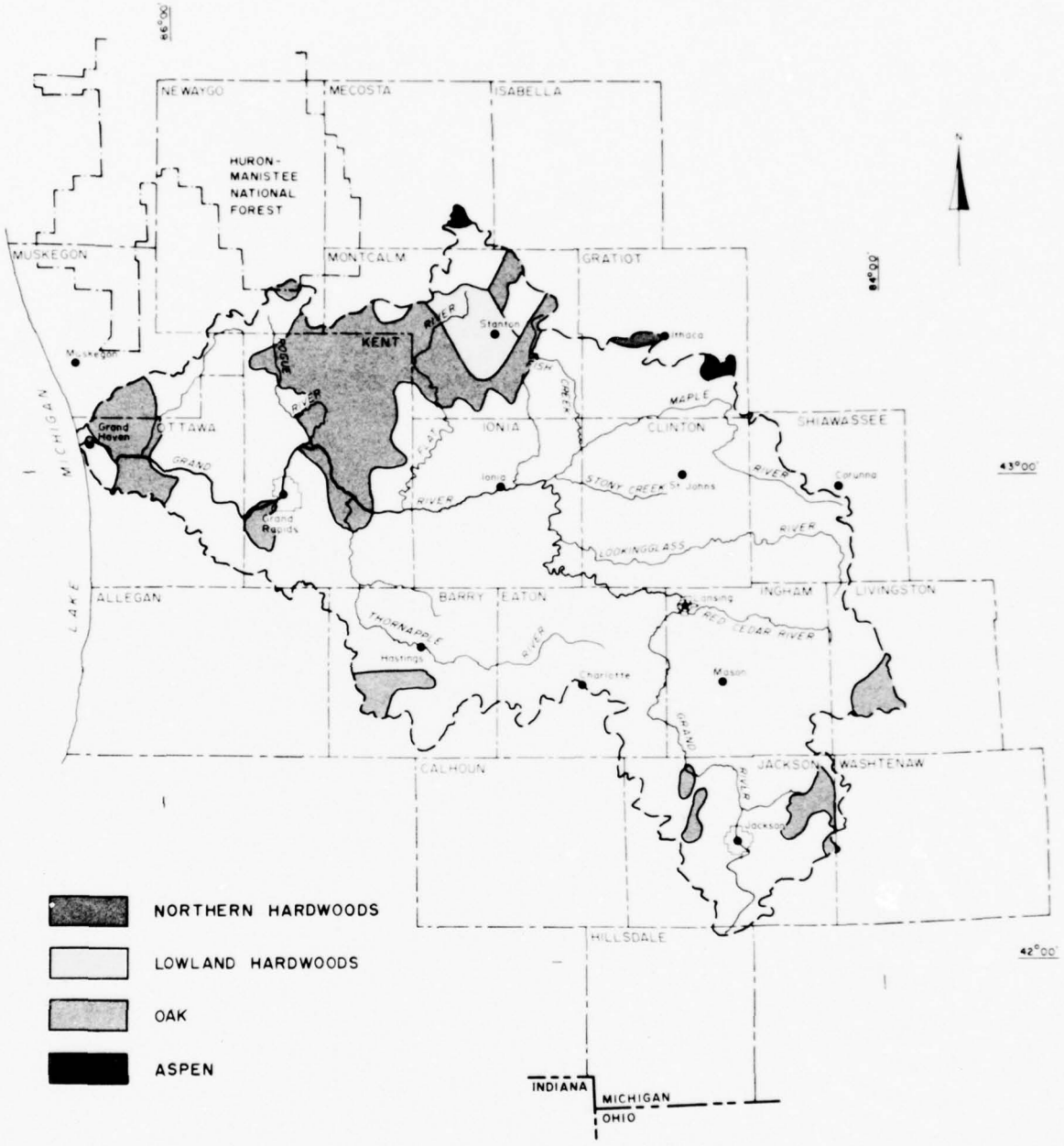


FIGURE 2–FOREST COVER IN AREAS 25 PERCENT OR MORE FORESTED, BY TIMBER TYPE, GRAND RIVER BASIN, MICHIGAN. (JANUARY 1, 1963)

SOURCE:
U.S.G.S. BASE MAP OF MICHIGAN AND
DATA SUBMITTED BY U.S. FOREST SERVICE,
NORTH CENTRAL FOREST EXPERIMENT STATION.

LAMBERT CONFORMAL CONIC PROJECTION
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TABLE 4 - Significant Characteristics of Soil Associations

Grand River Basin, Michigan

Soil Assoc.	Relief and Drainage	Parent Materials and Management Problems	Native Vegetation	Land Use and Major Crops
1	Nearly level to rolling with moderate to poor drainage characteristics.	Developed in clay or silty clay parent materials. Problems of soil structure and drainage exist.	Relatively wet and swampy, heavily timbered with elm, ash, and soft maple.	Suitable to general cropping when adequately drained if soil structure is maintained.
2	Level to hilly, well to imperfectly drained, poor drainage in depressional areas and natural drainways	Deep and durable soils developed in loam, clay loam, and silty clay loam drift. Associated wet areas influence size and shape of fields. Slope, erosion and drainage are problems.	Generally hardwood forest consisting of sugar maple, oak ash, hickory, elm and soft maple	Dairy and livestock with associated General crops and some cash cropping.
3	Nearly level to depressional areas which are naturally poorly drained.	Relatively high in organic matter, nitrogen and lime, moisture retentive. Developed in loams, silt loams and clay loams; have high natural fertility but problems of drainage.	Heavily timbered, primarily with elm, ash and soft maple.	Generally used for high-value crops, such as corn, field beans and sugar beets, but suitable for general cropping.

Sources: Clarence A. Engberg, State Soil Scientist, Michigan SCS, USDA, and Dr. Eugene P. Whiteside, Professor of Soil Science, Michigan State University, assisted in developing this table from the following publication: Whiteside, Schneider and Cook, Soils of Michigan, Michigan Agricultural Experiment Station, Spec. Bul. 402, December 1959, and Hill and Mawby, Types of Farming in Michigan, Michigan Agricultural Experiment Station, Spec. Bul. 206, September 1954.

TABLE 4 (Cont.) - Significant Characteristics of Soil Associations

Grand River Basin, Michigan

Soil Assoc.	Relief and Drainage	Parent Materials and Management Problems	Native Vegetation	Land Use and Major Crops
4	Level to hilly with slow to rapid surface drainage	Surface and subsoils slight to strongly acid, sandy loams with moderate water-holding capacity underlain with sand and gravel in places water erosion a serious problem in some areas, drainage needed in others.	Largely hardwood forest of oak, hickory, elm, ash and soft maple.	Moderate natural fertility adapted to a wide range of crops especially potatoes and all types of livestock production. Gravel and sand sources, hilly areas suitable for recreation and forestry.
5	Level to hilly and rolling to extremely rough with lakes, swamps and marshes in the basin-like associated areas, surface drainage good to rapid	Open and loose loamy sands with a finer textured subsoil. In some cases there is loam to silty clay at depths of 18 to 42 inches. Some with seasonally high water tables require drainage. Droughiness, low productivity and erosion on steep slopes are problems on others.	Hardwood forest of oak, hickory, elm and ash, marsh and short grasses.	Diversity of soils and unfavorable topography result in a wide range of field crops fruits and special crops. Many hilly areas are unsuitable for farming and are used for forestry, recreation, and sand or gravel enterprises.

TABLE 4 (Cont.) - Significant Characteristics of Soil Associations

Grand River Basin, Michigan

Soil Assoc.	Relief and Drainage	Parent Materials and Management Problems	Native Vegetation	Land Use and Major Crops
6.	Level to extremely hilly with some dunes along Lake Michigan, generally well drained but some poorly drained areas are included	Mainly deep sands to more than 66 inches, strongly acid, low water-holding capacity and low fertility. Level areas respond to irrigation and fertilization, wind erosion is a problem where the soil is tilled.	Hardwood forest of oak, hickory, elm and ash, sedges and short grasses.	Some general cropping, pasture, truck crops, small fruits, second growth forest, public recreation areas and rural residences.
7.	Level to depressional with poor to extremely poor natural drainage.	Organic mucks and peats of variable thickness developed from the partial decomposition of plant remains, with water level management fertility, frost and wind erosion problems.	Marsh and bog vegetation, short grasses, scrubby trees, elm, ash, soft maple, brush and shrubs.	Production of onions mint, celery, potatoes and truck crops small acreages of pasture and blueberries where the soil is very acid.

Table 5 - Soil Associations by County in Acres

Grand River Basin, Michigan

County	1	2	3	4	5	6	7	Misc.[1]	Total
Allegan	-	2,520	-	1,190	-	-	-	200	3,910
Barry	-	92,100	9,160	48,800	27,040	30,000	22,000	17,500	246,600
Calhoun	-	1,070	-	-	-	-	180	170	1,420
Clinton	7,020	193,640	28,440	71,090	15,800	9,130	25,980	15,770	366,870
Eaton	1,860	157,300	9,560	58,860	4,250	3,180	30,540	16,280	281,830
Gratiot	29,840	54,640	18,040	2,650	16,850	9,680	930	6,150	138,780
Hillsdale	-	-	-	3,900	-	-	-	730	4,630
Ingham	-	142,840	5,880	87,970	21,040	11,140	40,530	39,320	348,720
Ionia	700	148,080	29,090	75,200	64,500	10,170	22,780	17,770	368,290
Isabella	-	350	-	-	-	-	-	10	360
Jackson	270	75,420	13,390	67,500	48,640	15,850	52,200	43,430	316,700
Kent	11,860	132,720	21,440	88,940	131,810	29,190	40,140	84,420	540,520
Livingston	220	22,210	910	30,290	11,480	4,230	6,190	4,180	79,710
Mecosta	-	3,480	-	2,940	4,730	90	3,320	740	15,300
Montcalm	-	34,970	6,100	49,720	127,040	41,380	61,590	10,840	331,640
Muskegon	-	20,560	3,640	3,780	4,540	35,480	760	8,460	77,220
Newaygo	-	1,340	370	1,340	16,220	9,700	12,830	1,610	43,410
Ottawa	14,190	38,730	11,760	8,920	44,810	73,400	10,950	28,890	231,650
Shiawassee	-	-	61,740	49,670	7,950	5,960	16,610	8,950	150,880
Washtenaw	-	280	-	800	2,500	5,070	-	1,310	9,960
	65,960	1,122,250	219,520	653,560	549,200	293,650	347,530	306,730	3,558,400

1/ Includes urban land, lakes, and Federal land. Area of lakes having 40 or more surface acres was obtained from the Michigan Department of Natural Resources.

The Oak-hickory type is composed mostly of red, white and black oak; the lowland hardwood type includes elm, soft maple, and black ash. The northern hardwood species have the most economic value with oak, sugar maple, birch, beech, basswood, and hickory predominating, along with minor amounts of walnut and black cherry. Pine and some spruce are extensively planted for Christmas tree production in the western one-third of the Basin.

Forested land exists on all Soil Associations but is more heavily located on Associations 4, 5, and 6.

The 296,900 acres of pasture and range land supports a variety of livestock enterprises, including dairy and beef cows, sheep, horses, and fowl. Pasture lands are generally located on the rolling acres of Soil Associations 2, 4, and 5.

Areas of urban build-up, water areas, and other miscellaneous land uses totaling 785,250 acres make up the remaining 22.1 percent of the land counted in the CNI.

Trends of previous land use in the Basin are similar to those of southern Michigan. As reported by the Bureau of the Census, farm land acreage and farm numbers continued to increase through 1934, after which they began a continuous decline (Table 6, page 19). However, cropland increased through 1939 before beginning to drop. The average farm size has steadily increased since 1934 due to the reduction of farm numbers and consolidation of holdings. By 1964, the average size of farms increased to 141 acres. On a commercial farm basis, the average size of a farm in 1964 was 216.8 acres. Yet compared with surrounding states, the average farm size throughout Michigan remains small due to large numbers of part-time and residential farm units.

5. WATER RESOURCES

The Basin system is the second largest of the primary drainage systems in Michigan. Approximately 5,560 square miles are drained by the Grand River and its tributaries. The Basin has a maximum linear length of about 135 miles and width of about 70 miles. The one million-plus people heavily use the water for their personal, income-producing, recreational and esthetic needs.

Table 6 - Trends in Major Farm Land Use, Numbers, and Size 1/
Grand River Basin Study Area, Michigan

Year	Farms	Average Size	Land in Farms	All Farm Woodland	Other Land in Farms
	(Number)	(Acres)	(Acres)	(Acres)	(Acres)
1929	36,053	100	3,621,727	432,228	646,971
1934	40,521	94	3,789,809	457,066	704,146
1939	39,301	96	3,746,697	345,712	747,470
1944	36,068	104	3,738,342	404,312	795,257
1949	32,835	108	3,542,855	457,824	601,752
1954	29,274	116	3,403,171	425,426	556,566
1959	25,036	130	3,242,901	395,377	521,164
1964	21,474	141	3,036,549	363,222	422,243

Cropland

Year	Total	Harvested	Pastured	Other
	(Acres)	(Acres)	(Acres)	(Acres)
1929	2,542,528	1,808,086	429,315	305,127
1934	2,628,597	1,908,065	465,348	255,184
1939	2,653,515	1,802,164	596,920	254,431
1944	2,538,773	1,936,596	383,044	219,133
1949	2,483,279	1,795,322	415,741	272,216
1954	2,421,179	1,803,121	390,787	227,271
1959	2,326,360	1,722,838	292,424	311,098
1964	2,251,084	1,639,612	217,035	394,437

1/ Represents data from U.S. Census of Agriculture on a county basis for Barry, Clinton, Eaton, Gratiot, Ingham, Ionia, Jackson, Kent, Montcalm, Ottawa, and Shiawassee. These data will not correspond to hydrologic boundary data.

a. Availability and distribution The Grand River originates in the northeast corner of Hillsdale County some 15 miles south of Jackson, Michigan. Nine major tributaries contribute most of the runoff in the system: The Flat, Lookingglass, Maple, Portage, Red Cedar, Rouge and Thornapple Rivers, and the Crockery and Prairie Creeks. The seven rivers contain over half of the total Basin Drainage. The remaining drainage is accounted for by about 30 minor tributary creeks, including the Crockery and Prairie, ranging in size from 65 square miles down to 2 square miles.

Available water is found in three forms: ground water, surface water, and rain water. The average annual precipitation in the Basin is 31.4 inches but varies from 29.7 to 33.4 inches. During the six-month growing season, May through September, the average precipitation is generally more than half of the yearly average.1/

In the upper Grand River Basin, surface water comprises 62 percent of the total available water while 28 percent is ground water. In the lower Basin (below Ionia), ground water increased to 56 percent.

The annual runoff varies from approximately 7 inches to 12 inches; however, some areas show a minimum annual runoff of about one inch. Average annual runoff is about 9.1 inches; this produces about 2.7 million acre-feet which are available for capture and use in agricultural and other purposes.

b. Water Uses The principal water uses in the Basin include: (1) municipal water supply, (2) self-supplied industrial water, (3) recreation, (4) irrigation, (5) fish and aquatic life, (6) wildlife and stock watering, (7) hydropower, (8) commercial shipping, (9) cooling water supply, (10) waste assimilation, and (11) aesthetics.

General farm, livestock, and domestic water use requirements are presently 6,133 million gallons annually, mainly supplied from wells.

The present average annual irrigation rate is 11,370 acre-feet (about 3,705 million gallons). This amount includes some nonagricultural irrigation, such as golf courses, parks, and cemeteries. Available irrigation water sources are nearly evenly split: 51 percent as

1/ Also see Climate, Page 4.

ground water and 49 percent as surface water. A majority of the present irrigation is done with ground water from wells. Crop irrigation with surface water is more risky because of geographical variance in precipitation and the seasonal and yearly variance from the average.

The soils in the Basin which are suited to crops that thrive best with irrigation are located, for the most part, adjacent to Lake Michigan. In the lowland areas of the Lower Grand River Basin truck crops, such as onions, carrots, and celery are heavily irrigated. In the upland sites prominent irrigated crops include potatoes and fruits such as rasberries and blackberries.

In the Upper Grand River Basin, above Ionia, celery and onion crops account for the bulk of the irrigation in the lowland areas. In the upland areas, potatoes and cucumbers are the major irrigated crops.

Nonagricultural irrigation for such uses as golf courses, parks, and cemeteries accounts for between 10 and 20 percent of the irrigated acres of the Basin.

Drainage is related to irrigation in that they are both land and water management tools. Whereas irrigation is the regulated application of water to the land to improve its resource use, drainage is the planned removal of excess water from the land to also improve its resource use. One by-product of drainage, the farm pond, can provide such additional water uses as rural home-site recreation, rural fire protection, wildlife and livestock watering sites, and aquatic life habitat.

The Basin provides ample areas on and around its many lakes and waterways for water-based outdoor recreation. Swimming, boating, and fishing, along with the water-connected aspects of camping, hiking, and picnicking, are the major recreation activities.

c. Water Quality Despite the ample amounts of water, per se, in the Basin, pollution has degraded the quality of it in many places, particularly below the cities of Jackson, Lansing, Grand Rapids, and at the mouth of the Grand River. The pollution may take any of several forms: soil sediment, chemicals, human and industrial waste products, organic debris, and trash. The by-products include raised water temperatures, reduced oxygen levels, increased bacteria counts, and higher nitrate,

chloride, phosphate and ammonia levels. The result is a reduction both the amount and kinds of resource use.

Sediment from agricultural sources is present in surface waters. It affects the overall usability of the water to some degree, but its effect on agricultural production is rather limited in both degree and amount. Pollutants from agricultural sources, including fertilizers, insecticides, herbicides, and animal wastes, do occur in the surface and ground water; however, their magnitude is unknown. Generally, ground water quality is good except for localized areas of mineralization.

Many of the smaller waterways in the upper reaches of the Basin remain relatively unpolluted. Yet even these are in danger of major pollution because of the anticipated increase in water use for human and recreation needs.

6. FISH AND WILDLIFE RESOURCES

Fish and wildlife populations are varied and well-distributed in the Basin because of the wide dispersion of small "habitat units." Instead of broad expanses of uniform units having large stands of few-specied woodlands and 80 or 160-acre fields of grains or hay, the grassland, brushland, and woodland habitats occur as small-acre units interspersed with numerous water bodies and waterways. Many kinds of animals, birds, reptiles, and fishes are found in the Basin, but seldom in concentrated numbers.

a. Wildlife Populations Most of the larger animals, including bear, wolf, elk, and cougar which inhabited the forested lands before the advent of lumbering and farming, have disappeared. Population numbers of bobcat, otter, and beaver are quite low.

Other animals, such as the deer, have held their own or even increased in numbers with land clearance. Deer, along with certain game birds such as woodcock, pheasant, duck, and geese, and such small game as woodchuck, cottontail rabbit, and squirrel support a well-established sports industry along the Grand. Other wildlife species in the Basin include muskrat, fox, skunk, mink, weasel, and a variety of small mammals as well as many kinds of song birds and non-game water birds.

b. Fish Populations The Basin's populations of walleye, bass, pike. and trout have deteriorated in some areas due to localized pollution problems. Most of the fish population is composed of pan fish, principally the bluegill, and the so-called rough species, primarily members of the carp, sucker, and catfish groups. Good sport fisheries still do exist in many parts of the Basin.

c. Habitat Availability and Condition Wildlife tends to be more abundant in the transition zones at the edges of two or more adjoining habitat units. This phenomena is called "edge effect." Some land use practices in the Basin that indirectly achieve this effect include: (1) leaving the outside edges of grain fields uncut where they abut on brush and/or woodland; (2) leaving the brush and tree cover undisturbed in small "odd areas" which cannot be satisfactorily cropped, such as along property boundaries and field borders; (3) properly protecting and managing small woodlands for both wildlife and the timber value potential; and (4) retaining wetland areas and their accompanying aquatic plant growth in and around cropped fields where economically feasible.

Although all these wildlife-benefiting practices can be found in the Basin, there have not been enough applied to substantially increase the wildlife populations. Large-scale population increases require large-scale habitat improvement programs, both more of it and of a better quality.

Part of the needed increase is being met by urban residents who have bought rural lands. Some of them leave the city and move onto the land. Others only use it a part of the time, primarily for recreation use and wildlife and aesthetic appreciation. But generally most of them want to improve the land. They plant berry-producing shrubs, grain crops in food plots, and nut or cone-producing trees, all beneficial for wildlife.

7. QUALITY OF THE NATURAL ENVIRONMENT

Environment can be described as the living conditions for all forms of life. Ideally, all life shares a harmonious existence together. But mankind too often tends to view the environment only as it affects him, not as he affects it. As man changes and alters the natural resources

to meet his own needs, he also changes the naturalness of the resources and alters the quality of the environment.

The Basin has numerous areas, especially in rural settings, where people can enjoy meaningful experiences with the natural resources in the out-od-doors. They can hike, camp, fish, swim, relax, breathe fresh air, or just feel secure in the knowledge that the resources are still there for their appreciation. But there are also sites where industrial pollution with heat, smoke, and chemicals and agricultural pollution with sediments and high nutrient loads have degraded the total environment. Such contaminants reduce the amount and quality of outdoor recreation. They impair public health. They degrade the attractiveness of rural living.

The measure of quality of the environment is a subjective judgment. How good are the natural resources of the Basin? Or how bad are they? Rural roads lead to and through many natural resource attractions. They also expose many unnatural resource distractions.

a. Environmental Attractions Rural lands offer much in year-round aesthetic enjoyment. County roads duck in and out of small stands of freshly leafing aspen and hard maple. Sparkling streams and creeks skirt the bases of rolling crop and pasture lands. The bright green oat fields of early summer contrast with the forest greens of hardwood and conifer woodlots and field borders. The wheat stands tall and golden in its last days before harvest. The trees become a symphony of reds, golds, and browns. An early snow puts a crystal glaze on the corn stalks as the ears "hang heavy" with their weight and ripeness. A horned owl cruises a brushy field edge by moonlight on silent wings in search of a late winter meal of squirrel or rabbit.

Both rural and urban people can enjoy the recreational aesthetic pleasures offered in country areas. Many go to the lakes and rivers for the water sports - swimming, boating, fishing, and sunning. Others relax and have fun while camping, hiking, hunting, or watching wildlife in the forested uplands.

For some people, rural areas offer an escape - something better, something to remember. The air seems fresher and the water seems cleaner. The pace of living is more relaxed: easier on the heart, ears, and nerves.

The city-dwelling people of the Basin have some natural areas on or next to their urban lands that provide them a chance for enjoyment of the natural resources on a short-term basis. Parks, small woodland and swimming areas at pools or inter-city lakes are now and will grow even more popular.

The out-of-doors appeals to the five senses. People can see the growing trees and plants, can hear the songs and calls of birds and animals, can smell the pungent odors of apple blossoms or the heady aroma of freshly cut alfalfa, can feel the touch of snow on the face and wind through the hair, and can talk quietly about these experiences uninterrupted by man-made disturbances and innovations.

b. Environmental Distractions Not all of the Basin is as green, clean, and beautiful as Nature originally intended. A drive along a rural road on a balmy Sunday afternoon reveals that not all is natural beauty. Many a traveler has obviously contributed to the mess of cans, bottles, and other assorted refuse along the way. The barren spoil banks from past gravel pit operations, and the despoiling of the clean lake and river waters with industrial and human pollutants are further examples of mankind's destruction of the total environment.

Ten of the major categories of materials that may contaminate the air, water, and soil of the environment include radioactive substances, chemical air pollutants, airborne dust, sediments, plant nutrients, inorganic salts and minerals, organic wastes, infectious agents and allergens, agricultural and industrial chemicals, and heat.

The different kinds of materials or wastes often have interrelated effects. Most of the principal kinds of pollutants are wastes, or are associated with wastes. Together they detract from the attractiveness of rural living, the quality of the environment, and the well-being of the people's health in the Basin.

The following are some of the more important contaminants that result from agriculture and forestry endeavors and contribute to the overall degrading of the quality of the environment in the Basin. Quantitative data showing this degradation was not obtained for the Basin but is available on a national basis.[1/]

Sediments are primarily soil and mineral particles washed or blown into the water. This is the most widespread and significant form of pollution in water. Agricultural lands have long been identified with the sediment load in the waterways; however, urban, industrial, and highway construction sites and roadbanks also contribute significant amounts of eroded materials. In addition, pesticides and plant nutrents may be carried by sediment. The interaction of these substances in damaging the environment is related both to agricultural and urban communities.

Air pollution results from airborne chemical gases and sundry residues, natural dusts, and just plain smoke. Burning of agricultural and refuse material, plus brush and forest fires, both controlled and uncontrolled, contribute hydrocarbon materials and smoke. Burned forested areas have excessive runoff and a very high sediment delivery. They contribute to flood damages. Millions of tons of natural dusts, largely from soil blowing off fields under cultivation, and from highways and construction sites, enter the atmosphere each year. These particles often coat the foliage of nearby crops, ornamentals and trees, impairing both plant growth and quality.

Plant nutrients come from sewage, from animal manures, and from runoff and seepage from the land. These nutrients are needed for the mineral nutrition of plants. In part, they help cause excessive growths of aquatic plants; some of these plants create unpleasant tastes and odors that limits use of the water.

Organic wastes include such materials as sewage, animal manure,

1/ See Wastes In Relation to Agriculture and Forestry; USDA Misc. Publ. 1065; March 1968

crop residues, forest debris and food-and-fiber processing wastes. When they are carried in water, they exert a high demand on the dissolved oxygen supply. When dry upon the land, some are combustible, some produce odors, and some attract flies and vermin.

The use of synthetic organic chemical has been beneficial to man and his environment. But the discharge of some of these chemicals into the environment has brought on problems. These chemicals include such substances as household detergents and the more recent insecticides, herbecides, fungicides, and nematocides.

Despite their excellence as cleansing agents, detergents help cause malfunctioning of septic systems; they also carry phosphate, a key plant nutrient in promoting algae growth.

The potential contamination of the environment by herbicides and insecticides, particularly the chlorinated hydrocarbons, has been a matter of much public and private discussion. Although generally useful and necessary to agricultural production, some may cause damage beyond their targets, are slow to break down in nature, and are carried long distances while still potentially dangerous.

Seemingly, for every beauty spot in the Basin, there is one of more destructive factors working to overcome and to downgrade the aesthetic charm and appreciation of the natural area. Most of the destructive factors are man-introduced; the elimination of their destructiveness is also man's responsibility.

SECTION III

ECONOMIC DEVELOPMENT

1. HISTORICAL DEVELOPMENT OF THE AREA

Fur trappers roamed parts of the Basin area during the 18th century. They were instrumental in starting the pioneer settlements in the early 19th century near the present cities of Lowell, Ada, Grand Rapids and Jackson. Their flourishing furtrade drew attention to the area, and word of low land prices soon brought a rapid and steady growth in the population. Later settlers farmed small clearings in the densely forested area on a subsistance basis.

The first permanent farm settlements were established in the early 1820's in Kent County, primarily by people from New York. Others later came from Pennsylvania, Ohio, and the New England states. A similar pattern of settlement followed for the remaining portion of the Basin. Western counties were settled prior to the northern and interior counties which were settled as late as 1850.

Forest cutting and clearing began to increase in 1825 during the early settlement period. The first homesteaders sought out the upland hardwood areas. These pioneers were intent upon farming, and forest cover was considered a hinderance. The fallen trees were windrowed and burned, with no thoughts to their value.

Early settlers raised corn, wheat and clover hay primarily, with lesser crops of potatoes and apples. Small dairy herds and other livestock were maintained mostly to meet the owner's family needs.

Rapid growth of a pine lumber industry began after 1850. Early loggers harvested timber as if the supply was unlimited. As a result the expansion of the lumber industry was relatively short-lived. The peak year was reached by 1889. By 1925 the original supply of pine had nearly been exhausted. Much of the cut-over forest land was abandoned and forfeited for taxes. The remaining forest resources stayed in private hands.

By the early 1900's, most of the virgin forests had been cut to make way for agriculture. Farming replaced forestry as the major revenue-producer. Wheat and corn were grown on a large-scale basis, but

the dairy business provided the major farming income. Farm prices reached their peak dollar values in the early 1920s, then declined sharply during the Depression years when many farms were abandoned and forfeited for non-payment of taxes. After the 1930s Federal and public lands began to increase due, in part, to the abandonment of these "unwanted" lands.

Regrowth of hardwood stands and planting of conifer trees in the 1930s and 40s provided the basis for the improved timber production of today. Forest management involved both selective and block cutting, followed by re-forestation. Farm production also increased due mainly to improved cropping methods and better, time-saving equipment.

Since World War II, there has been no significant change in the acreage of forested land. At the present time approximately 15 percent of the Basin is forested, located mainly in the northwestern sector. Likewise, the pattern of woodland ownership has stabilized. Ninety-four percent of this area is in private ownership.

Improved farming techniques and equipment have drastically cut the needed labor force. Today, fewer workers produce more food on less land than ten years ago, causing farmers to leave their farms and migrate to the cities in search of other work. In 1960 the Basin had 2.5 million acres of cropland in farms, approximately 24 percent of the State's cropland. Major crops were corn and hay, used as inputs for the livestock industry, and wheat for cash sales.

2. GENERAL DESCRIPTION

Approximately one-seventh of State's population is found in the Basin--one-tenth of the State's total area. The Basin as a whole is characterized by an emphasis on the manufacture of durable goods. Dairy and general farming are the dominate agricultural enterprises. College-level educational facilities are located in the large cities. A combination of federal, state, and county roads serve all parts of the Basin population.

a. Population Characteristics Historically, the Grand River Basin's population growth has paralleled that of the United States. Between 1960 and 2000, the Basin's population is expected to increase from 1.1 million to 2.1 million persons. Since 1940, Michigan's

population and the population of the Basin have increased, on the average, about 2.2 percent per year. In 1960 about 530,000 people, over half the Basin population, lived in the three larger cities, Grand Rapids, Lansing, and Jackson, and their suburbs. The remainder lived in small towns and rural areas.

With this continuous population growth, it will be necessary to provide more jobs. But the favorable location of the Basin and its abundance of resources and skilled labor should be sufficient to attract new industry.

Since the increasing population will use more water, the demand on this resource must be recognized, calculated, and provided for if it is to satisfactorily serve the Basin needs.

b. Governmental and Educational Facilities Lansing is the State Capital, and houses the major governmental instutions of Michigan, and some major Federal agencies. Field offices of a number of the Federal and State agencies concerned with the Basin's land and water resources are located at the county level.

Michigan State University, the State's largest university, is located at East Lansing. This University plays a prominent role in the agricultural economy by offering many opportunities for interested persons to prepare themselves for a future in the broad fields of agriculture and natural resources. Scientific training is emphasized because modern agricultural and natural resources have been brought to their present high level of development through the application of scientific knowledge and principles.

The College of Agriculture and Natural Resources at M.S.U. offers undergraduate programs which lead to the Bachelor of Science degrees with majors in the following areas: Agricultural Biochemistry, Agricultural Business, Agricultural Communications, Agricultural Economics, Agricultural Education, Agricultural Engineering, Agricultural Mechanization, Animal Husbandry, Building Construction, Crop Science, Dairy, Fisheries and Wildlife, Food Science, Lumber and Building Materials, Marketing, Forestry, Horticultural Management, Horticultural Marketing, Packaging, Park Management, Poultry Science, Resource Development, Soil Science, and Wood Processing. Graduate degrees are offered in many of these same areas.

Other four-year institutions of higher education in the Basin include Calvin College and Aquinas College, Grand Rapids; Grand Valley State College, Allendale (west of Grand Rapids); Olivet College, Olivet (southwest of Lansing); and Spring Arbor College, Jackson.

c. Major Economic Activities Manufacturing is the predominant economic activity in the eleven county area which approximates the Basin. Major industries are generally located in and around Grand Rapids, Lansing and Jackson, and include transportation equipment, fabricated metals, and furniture and fixtures.

Farming on the $2\frac{1}{2}$ million acres of suitable farmland in the Basin is a highly diversified activity producing a wide variety of truck crops, row crops, dairy products, poultry, livestock, tree fruits, flowers, and general farm crops. In 1960, about 11,300 people, 1.16 percent of the Basin population, were engaged in agricultural production. Numerous other people were engaged in transporting, processing, and marketing the produce.

Woodland practices in the half-million acres of forest land produce a minor but steady part of the Basin economy. Recreation and tourism also contribute substantially.

d. Transportation The Basin is traversed by a well-improved network of county and township roads. Principal arteries running north-south are U.S. Highway 27 in the eastern portion and U.S. Highways 131 and 31 in the western portion; principal east-west highways are Interstate 96 and Michigan 21 and 57. Primary railroads are the Chesapeake and Ohio, Grand Trunk Western, New York Central, and Pennsylvania. Main marketing centers within the Basin are Grand Rapids, Jackson, and Lansing.

3. GENERAL ECONOMIC STUDY AND PROJECTION PROCEDURES

The general methodological approach taken in this study represents an attemp to account for the major forces affecting the general economy of the Grand River Basin.

a. Agricultural Studies The future agricultural use of the land and water resources in the Basin will reflect the kinds of food and fiber products that consumers demand in the future. Basin farmers serve both national and foreign markets and must compete with other basins and

regions in the production of agricultural commodities. In so doing, the future productivity of the natural and economic resources will have a major impact upon the amount and kind of agruicultural and forestry production forthcoming from the Basin. Several nonagricultural uses of land, such as recreation, transportation, and urbanrelated development, will also have a bearing on the amount and location of land available for agricultural and forest production.

(1) General Procedures

Briefly, the projection procedure has three basic components: (1) the determination of demand for agricultural products from the Basin, (2) the determination of the quantity and productive capacity of the land resource (supply), and (3) the estimation of the amount, kind, and location of agricultural production in the Basin, given the demand and supply conditions.

(2) Demand

The demand for agricultural products was determined from the national population projections and the expected per capita consumption rates of agricultural products. Trends in per capita meat, cereal, and dairy product consumption were developed from studies made by the USDA. Both the projected internal population needs and external export demands were considered in developing the national demand figures.

A portion of the national demand was allocated to a 42-county subregion in southern Michigan of which the Basin is a part. The allocation was consistent with productive efficiency in other parts of the country, being founded upon existing trends in regional production. Commodity specialists in the USDA made estimates of regional shifts in production based on relative efficiencies of production in the various regions. After determining the subregional share of national food and fiber requirements, the next consideration was locating the production areas, based on the Basin's resource potentials.

(3) Supply

The Inventory of Soil and Water Conservation Needs was used in determing the productive potential of the resource base. This source identified the kind and acreage of soils within the area and provided

the base for projecting the cropland available for agricultural production in future time periods. However, certain reductions were made in the agricultural resource base. They reflected the impact of such non-farm use as the development of urban-residential, industrial, commercial, recreation, and transportation sites upon the land. Further reductions were made to reflect the land requirements of minor and specialty crops. The remaining acreage of cropland and pasture was available to farm operators for use in agricultural production.

Projections of the yield potential of each soil association were made for all major crop and pasture uses. Michigan Agricultual Experiment Station and Soil Conservation Service specialists helped derive these projections which represented average yields reflecting the normal climatic, disease, and insect hazards expected to affect future yields. The projected yields take into account the improvements in technology applied to crop production, but do not include the gains obtainable through water resource development programs such as irrigation, drainage, and flood protection. These development aspects are discussed at length under Development Potentials.

In addition to developing the yield information for each soil association, production costs were developed for each crop. Thes figures reflect all costs incurred in land preparation, cultivation, and harvesting. They also account for such materials as seed, fertilizer, lime, twine, and pesticides.

(4) Projected Economy

Estimation of the amount, kind, and location of agricultural production was done through a complex economic budgeting procedure which used linear programming techniques and simulated what farmers will do with their resources given the criteria built into the projection model.1/

1/ A much more detailed discussion of the assumptions and procedures used in this methodology is available in Appendix O - Economic Base Study -Part IV, Comprehensive Water Resources Study, Grand River Basin, Michigan, January 1966.

The demand side provided estimated of the future agricultural products that will be required from the Basin. The supply side indicated the future crop and pasture production capacity of the basin soils available for agriculture. Use of economic budgeting model assumed that farmers will tend to organize their resources in an efficient manner to minimize costs of production and thereby maximize their net return. Given the demand and supply potential, the budgeting procedure simply selected the appropriate acreages of each soil which will be most efficient in meeting producation requirements for the Basin. For 1980, this allocation of resources is consistent with past production patterns.

Estimates of the farm income, rural-farm population, and farm labor force were also obtained as an end product of determining the location of agricultural activity.

(a) Farm Income Farm income is defined by the Agricultural Census to include the sales of crops and livestock, value of government payments, and the value of perquisites, such as the value of house rent and farm produce used in the home.

Problems of accurate counting and reporting exist in correctly evaluating the data from sales of farm products. Data for the number and value of livestock sold alive in 1959 were estimates bases on reports for sample farms only. The dollar value of sales was obtained from the farmer for cattle, calves, horses and mules. Average value, per head, for other livestock sold was obtained from United States Department of Agriculture data.

Since there was some question about the meaningfulness of a farm income figure due to its makeup, this study used the value of farm products sold as a proxy for that measure. The value of all farm products sold represents the major portion of farm income and is more easily measured; although, it is not a pure figure either.

Despite the problems inherent in the farm income value figure, it does represent the relative magnitude of farm business volume and from that standpoint can be considered a useful concept. To make a meaningful projection of such a value, several assumptions were made. Mainly, they took the form of estimating the proportion of particular

crop sold.

Prices used for estimating the value of farm products sold in the projection years were derived from the "Interim Price Standards for Planning and Evaluating Water and Land Resources," April 1966, released by the Interdepartmental Staff Committee of Water Resources Council. These prices have had the influence of abnormalities caused by weather and other shortrun circumstances removed, and the influence of direct government price support effects reduced. The size of sales of crops and livestock products depends on the assumptions build into the production estimates, and the assumed level of sales. Since livestock and livestock product sales volume was projected as such, the 100 percent sales assumption is consistent; however, the proportion of crops sold may be quite conservative. All of the cash crop items generally are sold, but the porportion of other livestock feed crops sold is an arbitrary estimate.

If the limitations of the farm income value are kept in mind and the figure used as a relative measure, rather than an absolute magnitude (similar to a value added concept) no real problems should arise. However, it must be recognized that there may be considerable double-counting, and perhaps, triple-counting in the farm income concept. Also, the value is intended strictly as a gross receipts value, or volume of business measure, not as a measure of net farm returns.

Abnormal weather conditions, either adverse or very favorable, could cause much different crop production than has been estimated. Likewise, cyclical patterns in livestock production might cause considerable variation is sales volume, as well as affecting the prevailing prices at a specific time in the future.

(b) Rural Farm Population[1/] Ideally, the definition of rural-farm population in the Grand River Basin should account for all of those people contributing to agricultural and forest production. The 1960 Cen-

1/ For greater detail and a discussion of the assumptions and limitations of the procedures used, see Appendix O - Economic Base Study, Part IV, Comprehensive Water Resources Study. Grand River Basin, Michigan, Part IV, January 1966, p.IV-83-90.

sus of Population closely approximates this ideal; hence, that definition is used in this study. Rural-farm population is more specifically defined as all rural persons living on farms of 10 or more acres selling at least $50 of products or on farms of less than 10 acres with sales of $250 or more.

There are people classified as farmers by the Census of Population who work part-time off the farm. Currently, the part-time farmer segment comprises a significant proportion of the rural farm population in the Basin. Off-farm work among the part-time farmers is likely to decrease somewhat as the larger, more specialized farms provide opportunities for full-time work. Part-time farming may continue to be prevalent in the future but to a lesser degree. In this case, the projected rural-farm population might be underestimated.

Projections of the rural-farm population were based on expected numbers of farms and the average size of farms. In order to estimate farm numbers, trends in the average size of farms were analyzed and projected by decades to the year 2020. For comparison purposes, trends in numbers of farms in the various acreage size classes were independently projected for the same years. The two projection methods produced similar results in terms of average farm size.

Estimates of rural-farm population for each decade were derived from projected farm numbers and the estimated number of people per farm household. Farm household size was developed by comparing trends in rural and urban areas. These trends were found to be slowly converging. On the basis of consultations with demographers,[1/] the trends are projected to continue in this direction. Current downward trends in urban household size are expected to continue. The size of rural -farm households is also expected to decline and approach the size of urban households as communication, mobility, standards of living, and educational levels improve in the rural areas.

1/ J. Allan Beegle, Professor of Sociology and Anthropology, and J. F. Thaden, Professor Emeritus, Michigan State University, East Lansing, Michigan. (Institute of Community Development and Services.)

(c) Rural Farm Employment The difinition of farm employment differs between the Census of Agriculture and the Census of Population. In the Census of Population, employment is determined at the place of residence and persons are counted as working in the industry from which they earn the greatest income. When using Census of Agriculture data, persons are counted on the basis of any place they work. Those with two jobs may be double counted. The definition of rural-farm employment chosen to be used in this report conforms closely with that used by the Census of population, but also accounts for seasonal labor which is not reflected in that series.

Rural-farm labor requirements, per acre, were developed from trends in total family and hired labor shown in the Census of Agriculture, and from survey data of operator, family, and hired labor by size and type of farm.[1/] Labor requirements, per acre, were developed for the farming operations expected to prevail in the future. These requirements reflect off-farm work and were developed for various sizes and types of farms. The result was a pure farm labor requirement which includes all labor necessary to meet production objectives regardless of the source of labor.

Total labor requirements were computed on an hourly basis for hired and total labor then converted to man-years, using the assumed hours worked per year in the Ad Hoc Water Resources Council Staff report.[2/]

(5) Development Potentials

Land treatment, irrigation, drainage, and flood prevention are the major water resource development activities considered by the USDA in evaluating measures for reducing the cost of producing the cost of

1/ Farming Adjustments in Lower Michigan, unpublished materials from a study made by the Farm Production Economics Division, Economic Research Service, USDA, 1963.

2/ Op. cit., National Economic Growth Projection 1980,2000,2020, July 1963, Appendix Table 3.

producing food and fiber to meet projected demands. The first step in making an analysis of one of these development activities is a determination of the physical potential for development. This section involves a description of the procedures used in determining the development potential. Acreages of the various soil groups in the Basin were categorized as to their potential for development and accessibility.

(a) Irrigation Irrigation is used to help increase yields, improve quality, and aid in plant germination. It also aids in controlling wind erosion, preventing frost damage, modifying climate, and applying fertilizer and pesticides.

The irrigation season usually begins in late April or early May with frost control for strawberries and wind erosion control on organic soils as an aid to germination. In total, the amounts used at this time are relatively minor. Usage continues on to a peak which usually occurs in late July or early August. Agricultural irrigation ends early in September, although some irrigation of parks, golf courses, etc., may continue into October.

In developing the physical potential for irrigation, CNI data were utilized extensively. The CNI categorized soils according to the primary limiting factors needing correction, and also indicated acreages within the particular categories which had been treated. Acreage estimated by the CNI as needing artificial drainage were used in calculating the proportion of each naturally wet soil that was adequately drained through artifical means. This acreage was combined with the acreage of naturally well-drained soils and used as the resource base of potentially irrigable land. The acreage of soils needing drainage could be considered as potentially irrigatable, but they would have to be drained first and the cost of drainage in addition to irrigation costs would raise production costs.

The acreage potentially available for irrigation was proportionately reduced to account for acreage reductions devoted to non-agricultural and minor crop uses. The remaining acreage was assumed to have no limitations which would restrict the availability of water or the ability of the plants to use it.

Irrigation normally takes place on those crops with a relatively high return so the cost of irrigation can be covered. Such crops are generally grown for cash sale and open-cultivated in rows. Therefore, the row crop limitations represent the real restriction on the acreage available for irrigation, since those crops with the greatest potential for irrigation are also row crops and subject to the limitations placed on soil uses. The acreage available for row crop production is assumed to decline less rapidly over the study period than does total cropland, due to improved management techniques adopted by farm operators.

Agricultural water resources developments have the potential of reducing the cost of production to society. Costs and returns to irrigation were analyzed through the economic budgeting procedure to determine whether overall costs of production could be reduced through the introduction of agricultural irrigation.

Monthly weather data for the 36-year period from 1929 to 1964 were used in the analysis. These data are averages of the weather prevailing across a weather district. The Statistical Reporting Service publishes annual average crop yields for Crop Reporting Districts in each state, which in the Midwest closely approximate or coincide with the weather districts. Coefficients of reduced crop production per unit of moisture deficiency were developed from regression analysis of average crop yields and certain weather variables during growing season months. These coefficients give average yield reduction associated with below-average moisture conditions. The reduction is also the yield response that can be expected from bringing soil moisture up to normal through supplemental irrigation. The long-term average deficiency and the quantity of irrigation water necessary to remove it can be determined from the weather data available.

Irrigation may pay for itself over one growing season if a farm operator has access to it in times of extreme drought. However, it is quite doubtful that investment of the size necessary for an irrigation system would be made based on a once-in-10 to 15-years change of such a drought. For projective purposes it was, therefore, assumed that if the farm operator could not cover the costs of irrigation under average weather conditions, he would not invest in irrigation.

The 36-year average of the moisture deficiency variable is calculated from adjusted weather data which reflects water-holding capacity of a particular soil and appropriate root zone for a particular crop within each weather district. The average deficiency is multiplied by the relative yield reduction from a unit of deficiency to determine the percentage increase in yield in future years attributable to removing the average deficiency with supplemental irrigation.

In this manner, response to irrigation was determined for wheat, corn, corn silage, soybeans, dry beans, potatoes, and hay. The assumed growing season for use in determining soil moisture deficiency was June, July, August, and September for all crops except wheat. For wheat the previous September and October and the current May and June weather factors were used in the calculations.

In addition to the yield response due to irrigation alone, another positive response was added for the assumed yield increase associated with the improved management inputs. By removing weather as an uncertainty through irrigation, landowners would feel more assurance of getting economic benefits through applying these inputs. They include greater application of seed in closer row spacing, increased use of fertilizer, and better use of labor and equipment. The additional inputs enter into the calculation of costs associated with the increated yield levels from irrigation. It was assumed that with the lower levels of moisture deficiency the likelihood of reduced yields would be of less concern. Therefore more of the management inputs would be directed toward improving the yield levels in non-irrigated crops. A 15 percent quality increase was added to irrigated potato yield coefficients in the budgeting model to account for the larger proportion of U.S. No. 1 potatoes through controlled moisture conditions. This is especially important in the production of Russett Burbank variety of potatoes.

Production costs for irrigated crops include the annual fixed costs of the irrigation system, costs of applying water, and costs of associated management inputs outlined above. The annual fixed cost of the system is made up of the amortized cost of the pump over 9 years and the amortized cost of the sprinkler system at 20 years for pipe and 10 years for fittings and sprinklers (Table 7, page 41 and Table 8, page 42).

TABLE 7 - Original and Amortized Cost of Hypothetical Sprinkler System [1/]

Grand River Basin, Michigan

Component	Unit	Quantity	Price List	Actual Cost	Life (Years)	Amortized Cost @ 6%
Aluminum Pipe						
7" Main	ft.	2,640	$ 1.53	$4,039	20	$352.12
6" Lateral	ft.	1,320	1.125	1,485	20	129.46
Giant Sprinklers	ea.	4	103.50	414	10	56.25
Sprinkler Stands	ea.	8	37.87	303	10	41.17
3" Gate Valves	ea.	8	10.13	81	10	11.01
7" x 6" Tee Valves	ea.	7	31.85	223	10	30.30
6' x 6" Valve Opening Elbow	ea.	1	32.00	32	10	4.35
Misc. Fittings	--	-	--	180	10	24.46
Total				$6,757.00		$649.12
Cost per acre				$ 84.46		$ 8.11
Repairs and Maintenance						$ 2.53

1/ Developed in consultation with Agricultural Engineers of the Michigan Agricultural Experiment Station and Soil Conservation Service

TABLE 8 - Original and Amortized Costs of Water Supply Pump and Variable Costs of Operating the Hypothetical System 1/

Grand River Basin, Michigan

Component	List Cost	Actual Cost	Life (Years)	Cost-Salvage Value	Amortized Cost @ 6%
6" x 6" Cent. Pump with 100 h.p. gasoline engine. Wheel mounted, incl. suction line and strainer.	$3,615	$3,254.00	9	$2,892	$425.18
Cost per Acre (80 acres)		$ 40.68			$ 5.31
Repairs and Maintenance					$ 1.22

	Variable Costs				
Item	Use	Cost	Cost/hr	Acres/set	Cost/hr. (acre)
Fuel (75 BHP)	7.5 gal/hr.	$ .20	$1.50	3.33	$ .45
Attendance	.05 hr./hr.	1.58/hr.	.08	3.33	.02
			Cost/irrig.		
Labor:					
Corn, corn silage	2.0 hr./irrig.	1.58/hr.	3.16		
Soybeans, dry beans and potatoes	1.8 hr./irrig.	1.58/hr.	2.84		
Wheat, alfalfa and other hay	1.6 hr./irrig.	1.58/hr.	3.53		

1/ (See Footnote Table 7) SAME

In addition, a maintenance charge of 3 percent of the equipment's original cost is added per year. This hypothetical system is designed to irrigate 80 acres with 2 inches of water in two weeks or less. That is, in the case of extreme drought conditions when no rainfall occurs for many weeks at a time, this system will supply all the water needed by most crops if operated around the clock. For cost purposes, total fixed charges were averaged over 80 acres to put them on an acre basis.

Variable costs fluctuate mainly with the quantity of water applied per acre. They consist of: fuel - 7.5 gal/hr @ $0.20/gal = $1.50 hr.; attendance - 1 man-hr attendance/20/hrs/of system operation @ 1.58/man hr. = $0.08/system-hr; labor @ $1.58/hr (acre charge per irrigation: 2 hrs. - corn and corn silage, 1.8 hrs. - soybeans, dry beans and potatoes, and 1.6 hrs. - wheat and hay). The per acre charges for associated management were also added.

Gross Basin-wide irrigation acreages, under the assumed conditions of economic efficiency, average moisture loss, and other weather relationships, should be considered as an optimum. However, it must be remembered that these acreages were developed in the face of no restrictions upon water availability and, as such, should be used as a guide to the type of soils and crops which show a potential for irrigation. To this total will be added the irrigation requirements for minor crops.

Since minor crop acreages were determined separately in the economic base study, they were removed from the land base used for general field crop production and did not become incorporated in the economic budgeting model. However, such specialty crops as tree-fruits, small fruits, and vegetables are currently irrigated to a much larger extent than are field crops. This is mainly due to their high value and critical need for water at certain times of the growing season. Therefore, separate estimates of irrigation water needs were made for these crops in consultation with irrigation specialists at the Michigan Agricultural Experiment Station.

(b) Drainage The same general procedure used in developing the economic potential for irrigation was also used in analyzing and projecting drainage potential in the study area. Available acreage for drainage and the additional costs were incorporated into the economic

budgeting model along with the costs and returns for similar soils not receiving further water resource development. The model compared the relative profits of crops from soils in which the economic benefits of additional potential drainage were included against the profits from those soils with no further drainage potential. Results from this procedure represent the least costly of all production alternatives in terms of crop yields on both drained and undrained soils.

In developing cost data for the analysis of drainage potential, county Agricultural Stabilization and Conservation Committee records were used. These data, for the year 1965, were the basis for ASC cost-share payments to farmers for installing approved drainage facilities. They reflect the current cost of tile, trenching, and materials on an area basis and were aggregated in developing one cost figure per subarea for each soil group.

Drainage specialists in the SCS provided assistance in estimating tile and open ditch needs for each soil with a wetness problem. All estimated needs reflected the recommendations for tile spacing, blinding, and surface ditching. Annual average cost per acre for an adequate drainage system ranges widely (Table 9, page 45). The cost spread reflects the varied drainage requirements of the different soil groups plus the subarea cost differential for trenching. Large differences in trenching costs reflect varying percentages of level land among the different subareas and the degree of difficulty (increased by stoniness and uneven terrain) in making the trenching cuts. The cost of tile installed is amortized at 6 percent for 30 years, while the cost of open ditches reflects a 20-year amortization, also at 6 percent.

The CNI data shows a certain acreage of wet soils in the Basin which both need to and can be economically drained by 1975. Other areas with excessive wetness were considered economically infeasible to drain. They will likely be shifted by 1975 into a land use category other than cropland, such as pasture, forest, or "other." The difference between total acres and those needing treatment is considered that acreage having had treatment applied and not in need of additional drainage.

The cropland acreage on which some form of artificial drainage was recommended was reduced proportionately to account for non-agricultural

TABLE 9 - Annual Costs of Drainage Including Tile, Ditches, Materials and Maintenance, Plus Recommended Spacing and Coverage by Tile and Ditches, by Subareas Within the Southern Michigan Subregion, 1965 1/

GRAND RIVER BASIN, MICHIGAN

Soil Group	Recommended Tile Drainage		Recommended Ditching			Annual Cost of Drainage By Sub-Areas (Tile, Ditch, Materials, Etc.)				
	Spacing	% Drained	Deep	Shallow	Total	1	2	3	4	5
	(Rods)			(Percent)		(Dollars Per Acre)				
1(A) 2/	4	70	0	50 4/	50	7.16	6.41	8.46	7.34	9.21
1(B)	4	70	0	15	15	6.68	5.93	7.98	6.86	8.73
2(A)	5	100	5	15	20	8.16	7.27	9.69	8.37	10.58
2(B)	5	100	5	5	10	8.06	7.17	9.59	8.27	10.48
3(A)	5	100	5	10	15	8.11	7.22	9.64	8.32	10.53
4(A)	6	100	5	5	10	7.79	7.16	9.21	7.67	9.80
4(B)	6	100	5	0	5	7.74	7.11	9.16	7.62	9.75
5(A)	7	100	5	0	5	6.09	5.52	7.19	5.99	7.65
6(A)	6	10 3/	2	2	4	0.89	0.82	1.04	0.83	1.10
7	7	100	10	0	10	5.52	4.95	6.49	5.65	7.06

1/ Annual Cost of tiling and ditching amortized for 30 years and 20 years respectively at 6 percent

2/ Capital letters designate slope ranges A = 0-2%; B = 2-6%

3/ Represents random tiling to reach low wet spots in fields

4/ Reflects land smoothing and leveling primarily

and minor crop uses. This was the same method used in determining potentially irrigable cropland. The remaining cropland was considered potentially available for drainage.

In determining the potentially drainable cropland, several assumptions were made: (1) all such land is considered fully available, in a purely physical sense, for drainage; (2) no limitations exist to prevent achieving the full physical potential; that is, channels are assumed capable of carrying the excess volume of flow brought about by additional drainage, and outlets are assumed to exist for all farms; (3) where these assumptions were not accurately reflected in their field application, the economic potential for development was adjusted accordingly.

b. Forestry Studies The projection of the timber resource, its harvest and resulting employment, are derived from projections for all of Michigan. Inventory and growth data are based on two surveys by the United States Forest Service, one in 1935 and the other in 1955. The forest inventory figures were updated to January 1963 from base data collected between 1946 and 1949, and subsequent estimates of timber use based upon biennial timber production records.

The projection of timber products output and timber cut rests upon information from periodic studies made since 1935. These timber cut figures for all of Michigan were adjusted, using trends and other information from the Basin, to obtain figures for 1952 and 1962, and for projecting into the future. The estimates of the future timber supplies have been made in the light of forest conditions described in this study, and on the assumption that levels of timber management in the future will be roughly similar to those of recent years.

c. Nonagricultural Studies The procedures followed in projecting non-agricultural economic activity differed significantly from the economic model for agriculture.[1/] Population estimates were derived from Census "Series B" projections for the United States. The rates of

1/ A much more detailed discussion of the assumptions and procedures used in this methodology is available in Appendix O - Economic Base Study - Part I, Comprehensive Water Resources Study, Grand River Basin, Michigan, January 1966.

increase developed for each subarea reflected historical growth patterns that were higher in the three Standard Metropolitan Statistical Area subareas than in the more rural subareas. Estimates of the number of households were derived from population projections and from an analysis of the ratio of dependent population to productive population. These estimates served as the base for household water use, a guide to demand for certain products or services, and a check against projections of employment.

On the basis of estimated population totals at bi-decade intervals of the study period, employment figures were projected for those sectors of the economy closely related to population growth. Employment was also projected for the major industries that satisfy economic demands outside the Basin. These figures were coordinated with the agricultural and forest-industry employment projections. Internal consistency was also maintained through checks against the labor force and its components, employment and unemployment, and against labor force participation rates by age groups as projected for each of the major industries in each subarea.

Projected levels of economic activity in key water-using industries within the Basin were derived from estimated rates and trends of national growth, then adjusted for known regional divergencies. Estimates of industrial water needs were developed from these adjusted projections and from a recent study of water use rates of similar industries in Ohio.[1/]

Estimates of the land requirements for the expected increase in population, expanded commercial and industrial activity, and transportation and recreation needs were derived from the projected economic activity in the Basin. These land requirements were removed from the agricultural resource base.

4. PRESENT AND PROJECTED MAJOR LAND USE PATTERNS

As the economic activity, population growth, urbanization and expanded services increase, more pressure will be placed on the agricultural and forestry resources. Changes in the use of these land resources will occur.

1/ Industrial Water Use in Ohio, Ohio Department of Natural Resources, Division of Water, Report No. 8, Ohio Water Plan Inventory, Dec. 1960

TABLE 10 - Distribution of Land Use By County 1/ - 1958

Grand River Basin, Michigan

County	Cropland	Forest	Pasture	Miscellaneous 2/	Total
			(Acres)		
Allegan	2,030	490	320	1,070	3,910
Barry	102,620	37,800	25,070	81,110	246,600
Calhoun	750	150	140	380	1,420
Clinton	263,180	32,700	33,620	37,370	366,870
Eaton	187,490	26,100	23,470	44,770	281,830
Gratiot	91,320	20,400	13,930	13,130	138,780
Hillsdale	2,160	710	520	1,240	4,630
Ingham	194,650	38,100	35,980	79,990	348,720
Ionia	209,970	44,200	47,980	66,140	368,290
Isabella	160	110	40	50	360
Jackson	132,650	43,400	26,210	114,440	316,700
Kent	252,120	96,900	20,870	170,630	540,520
Livingston	47,500	16,100	6,920	9,190	79,710
Mecosta	5,020	6,000	1,820	2,460	15,300
Montcalm	210,310	70,800	23,560	26,970	331,640
Muskegon	27,360	19,850	1,680	28,330	77,220
Newaygo	8,110	22,100	2,890	10,310	43,410
Ottawa	106,870	34,300	12,180	78,300	231,650
Shiawassee	92,230	23,500	18,850	16,300	150,880
Washtenaw	3,500	2,540	850	3,070	9,960
Total	1,940,000	536,250	296,900	785,250	3,558,400

1/ Adapted from inventory of soil and water conservation needs.

2/ Includes urban built-up, water areas, farmsteads, idle land (not idel cropland), wildlife areas and other areas not classified as cropland, pasture and forest.

Expected trends in major land use reflect definite long-term shifts in the acreage of certain uses. Continuous declines are projected to occur in the cropland and permanent pasture acreages as these uses give way primarily to urban and related development (Table 10, page 48 and Table 11, page 50). The amount of land needed for urban buildup, which includes acreage for recreation and transportation facilities, is expected to more than double from 1960 to 2020.

The acreage available for agricultural use will decrease during the projection period although the total tonnage of all products is expected to rise. Adoption of recommended production practices, crop varieties, and new techniques will enable farmers to increase output per acre, as they have in the past. However, this will not be sufficient to meet expanding requirements in the long run and the current relatively large acreage of non-producing cropland will be called into production by 2020. The acreage of water areas is assumed to double in the period based on the projected need and expected progress in water resource development. The acreages in miscellaneous and forest land uses show some interrelated irregularities during this time. Between 1960 and 2000, some of the miscellaneous acreage is expected to revert to forest cover and, therefore, will shift in land use. But after the year 2000 the demands upon forest land for non-forest uses will reverse this trend; miscellaneous lands will then increase while forest lands decrease.

5. AGRICULTURE AND RELATED ECONOMIC ACTIVITY

The future agricultural use of the land and water resources in the Grand River Basin will reflect the kinds of food and fiber products that consumers demand in the future. Non-agricultural uses of land, such as urban-related, recreation, and transportation development, will have a bearing on land available for agricultural production.

The previous section on land use patterns presented a brief summary of the trends associated with all land uses in the Basin. The following, more detailed material describes the present and projected economic levels for the crop and livestock production enterprises, then considers the implications regarding farm income, population, and employment.

a. Present and Projected Crop and Livestock Production Basin farmers serve both national and foreign markets and must compete with other basin and regions in the production of agricultural commodities. The

TABLE 11 - Acreage of Major Land Use For
1958 And Projection 2020
Grand River Basin, Michigan

Land Use	1958	1980	2000	2020
		(1,000 Acres)		
Cropland	1,940.0	1,863.8	1,763.2	1,628.6
Forest Land	536.2	643.6	735.5	698.7
Pasture	296.9	269.8	244.2	218.4
Urban Built-up	279.7	356.2	454.9	591.4
Water Areas 1/	27.2	36.3	45.4	54.5
Other Miscellaneous	478.4	388.7	315.2	366.8
Total	3,558.4	3,558.4	3,558.4	3,558.4

1/ It was assumed that developments to meet the demands for water resource needs would double the water areas by 2020.

extent and reliableness of their productivity will contribute accordingly to the agricultural land base of the Nation.

(1) Major Crop Enterprise Patterns

Cropping patterns were derived through the use of the economic budgeting model which simulates the actions of farmers in the use of their land. For study purposes the southern Michigan subregion was divided into five subareas mainly on the basis of type of farming. Historic production trends in the subareas in recent decades were made a part of the economic budgeting model for the 1980 projections to account for institutional restraints to economic efficiency. A proportion of the current acreage of each crop in a particular subarea was required to be produced in that subarea to represent these trends. Feed grain requirements were linked to past trends in livestock production.[1/] The minimum cost efficiency aspect of the economic budgeting model was used to distribute remaining requirements to the subareas in the 1980 projection of land use. For subsequent projection years, the five subareas were allowed to compete with each other on a minimum-cost efficiency basis. Land use was based on these efficiency criteria and reflects the ability of farmers to use their soils to compete within the subregion.

Basin cropland and pasture use did not conform closely with the general pattern of use in the State in 1958 (Table 3, page 12). The Basin contained more than 54 percent cropland and about 8 percent of all pasture in farms compared to State-wide percentages of nearly 29 and 5 percent respectively.

The agricultural cropland expected to be used was divided into four commodity groupings for report purposes (Table 12, page 53). The food crop grouping consists of the four cash crops -- wheat, soybeans, dry field beans, and potatoes. Components of the feed crop grouping are corn, oats, and barley. The roughage crop grouping includes corn silage, alfalfa mixture, other hay, and cropland pasture.

1/ Appendix O - Economic Base Study, Part IV, Comprehensive Water Resources Study, Grand River Basin, Michigan January 1966. Appendix Table 2.

The fourth grouping, other crops, consists of minor crops such as fruits, vegetables, minor small grains, hay crops out for seed, sugar beets, mint, and miscellaneous crops. Only the fruit, vegetable, and sugar beet crops have significant acreages in production. Estimates of the yearly acreage required to produced the needed amounts of these three crops for the Basin were derived from the average per-unit yields and the subregional supply and demand for these crops. The expected acreage of small fruits was considered as one category and derived through historical relationships with the projected population growth. The vegetable and sugar beet acreages plus the remaining minor crops were grouped into another category. A constant acreage was reserved for them that was expected to supply the needs for the projected Basin population, yet still allow for crop substitution adjustments to varying market conditions and for improved crop production.

Idle cropland includes land which previously was cropped but is now retired from production. This idle land is considered potentially available for cropland in one of the commodity groupings because it has not been purposefully changed to fulfill other land uses, i.e., planted forests, seeded pastures, recreation sites, and urban build-up. Nor has it been allowed to accidentally revert by ecological succession to woodland or wild pasture land. In addition, some acreage is "summer fallowed" or planted to soil conserving crops, all of which are included in the idle cropland figure.

Major cropland use considers all potential agricultural land available for the production of sizable and economically significant crops. This includes the acreage expected to be planted to such crops as corn, wheat, oats, barley, alfalfa, beans, potatoes, cucumbers, onions, celery, beets, apples, peaches, pears, cherries, plums, strawberries, and the "cane" fruits.

The projected row crop acreage is included as part of major cropland use. These row crops include all the above listed major crops except the close-sown grains, alfalfa, and orchard crops. Such minor crops as mint and carrots are also row crops.

Table 12 - Acreage of Major Crop Usage for 1960 and Projections by Decade to 2020
Grand River Basin, Michigan

	YEARS						
	1960	1970	1980	1990	2000	2010	2020
	(1,000 Acres)						
Food Crops	383.9	291.4	199.0	330.8	463.1	454.2	445.8
Feed Crops	564.7	438.1	311.3	235.6	160.5	294.8	427.6
Crop Roughages	577.6	539.9	502.4	562.6	622.6	583.4	543.8
Other Crops	93.6	88.4	83.0	114.9	147.0	59.5	172.0
Major Cropland Use	1,619.8	1,357.8	1,095.7	1,243.9	1,392.5	1,490.9	1,589.2
Non Producing[1/]	320.2	544.1	768.1	569.6	370.7	205.1	39.4
Total Cropland	1,940.0	1,901.9	1,863.8	1,813.5	1,763.2	1,696.0	1,628.6

Source: Economic Base Study Appendix "O". January 1966.

1/ Represents the remaining acreage of cropland available for production but not required to meet estimated Basin demands.

The agricultural acreage available for major crop production exceeded 1.8 million acres in 1960, once the land required for urban uses and minor crops was removed (Table 13, Page 55). Acreages of minor crops were considered spearately.

Cropland acreage availabe for the production of major crops is projected to decrease steadily over the study period reflecting the increased removal of land for urban-related and minor crop uses. Some of the converted land will be highly productive cropland, but much of it will not be suited for continuously growing the same kind of crop. Improved farming and resource management practices, however, will help achieve a greater productivity on the less prosperous acreage, thus still meeting the crop needs.

Frequent cultivation of row crops tends to break up the soil structure which encourages soil loss through both wind and water erosion on certain soils. Consequently, less than full use of these soils is a recommended practice for row crop production and these limitations were imposed in the budgeting model. Over time, more land is projected to be available for row crops as recommended management techniques are assumed to be adopted. The availability of nearly 1 million acres for row crop production in 1960 reflects the recommended minimum rotation, consistent with management practices of the day, which would hold soil loss within the Soil Conservation Service guidelines set out in the Technical Guide for 1962. Projected increases in cropland available for row crop production are based on the assumed adoption by 1980 of recommended conservation cropping systems set out in the Technical Guide of 1964. Additional improvements in management of five percent were assumed for 2000 and 2020.

Therefore, acreage available for row crop production is projected to become proportionately larger during the study period, rising from 53.5 percent of the major cropland acreage in 1960 to 76.2 percent, 79.3 percent and 82.7 percent, respectively, in 1980, 2000, and 2020. Actual useage of row crop acreage was 307,100 acres, 321,400 acres, and 508,700 acres in those time periods, however.

TABLE 13 - Acreage of Cropland Available for Production of Major Crops for 1960, and Projections to 1980, 2000 and 2020 1/

Grand River Basin, Michigan

Soil Association	Acreage Available for Major Crops Projected				Acreage Available for Row Crops 2/ Projected			
	1960	1980	2000	2020	1960	1980	2000	2020
	(1,000 Acres)				(1,000 Acres)			
1	48.3	47.5	45.0	42.0	23.9	30.5	30.3	29.7
2	706.5	687.5	637.8	582.6	357.4	481.3	476.8	450.9
3	165.0	162.4	151.4	139.3	142.6	158.3	151.4	139.3
4	537.3	516.0	451.8	398.9	261.3	378.8	349.4	320.9
5	249.3	235.5	219.3	195.4	112.7	193.7	176.7	175.2
6	84.2	82.1	77.4	70.6	32.6	64.3	63.5	60.4
7	56.7	50.6	37.0	29.5	57.2	50.6	37.0	29.5
Total	1,847.3	1,781.3	1,619.7	1,458.3	987.7	1,357.5	1,285.1	1,205.9

1/ Economic base study, Appendix O - January 1966

2/ These acres represent a proportion of the total cropland available for the production when management withholds soil loss to a recommended minimum. The recommended minimums conform to Soil Conservation Service Guidlines.

The acreage of idle cropland is predicted to reach a maximum in 1980 due to several factors, the more important of which include the introduction of greater efficiency in production of crops and livestock, large increases in per acre yields, and absolute decreases in some of the food and fiber needs from those in 1960. After 1980, the percentage of idle acreage declines continuously in each decade to 2020. The unused cropland is generally less productive and consists mainly of soil in associations 5 and 6. In some instances, these soils are better suited to the more extensive uses, such as recreation, forest or permanent pasture.

(2) Major Livestock Enterprise Patterns

The ability to produce feed grains and roughages has a major influence on the location of livestock production. Livestock production, however, do not change greatly from current proportionate shares. Projected trends for the 60-year study period are for increased shares of all livestock products except beef and veal. Changes in shares of turkey, pork, and egg production are negligible.

Current production of beef and veal is one-quarter of the subregion's production, while lamb and mutton production equals nearly 33 percent (Table 14, page 57). Basin farmers produce more turkey than the remainder of the subregion. Shares of milk and egg production both currently exceed one-quarter of the subregion's production. Pork production is more than one-third, and chickens are 35 percent of the total subregional production of these products.

Total tonnage of all livestock products produced in the Basin is projected to increase by 127 percent between 1960 and 2020. Greatest increases in particular commodities come in turkey, beef, veal, pork, and milk production. The smallest increase occurs in chicken production. Egg production, and the production of lamb and mutton, increases by about four-fifths over the 60-year period. Decreased tonnages of certain product groups--eggs, chickens, lamb, and mutton--between 1960 and reflect trends in declining per capita consumption of these items, along with a smaller subregional allocation of national demand.

TABLE 14 - Production of Livestock and Livestock Products for 1960, and Projections to 2020 [1/]

Grand River Basin, Michigan

Livestock Item	Yearly Average 1959-61	Current Basin Share of Sub-region Total	Time			Increase from 1959-61 Average to 2020
			1980	2000	2020	
	(1,000 tons)	(percent)		(1,000 tons)		(percent)
Beef and Veal	47.2	25.4	59.4	87.1	112.6	138.6
Lamb and Mutton	2.8	32.6	2.7	4.0	5.9	110.7
Pork	32.5	30.4	39.8	60.1	80.4	147.4
Chicken	6.6	34.9	4.1	6.6	8.8	33.3
Turkey	4.9	57.0	7.5	11.3	15.5	216.3
Milk	575.1	28.8	690.1	1,056.3	1,443.4	151.0
Eggs	15.9	29.0	15.4	21.6	28.9	81.8
Total	685.0	--	819.0	1,247.0	1,695.5	147.5

1/ Economic Base Study, Appendix O.

b. Present and Projected Basin Farm Income, Population and Employment Projected changes in production levels, increased size and specialization of commercial farms, and the adoption of new labor-saving technologies all have important impacts on the rural-farm population and labor force of the future.

(1) Farm Income

Farm income by source of sales, the quantities produced and sold under the stated assumptions, and the prices used to calculate sales values are set forth in Table 15 (page 59) for the 1960 projections of future sales proportions. Farm income sources are the same in 1980 as in 1960, due to the restriction placed on the economic budgeting model requiring a share of all crops to be produced in the same areas they occupied during 1959.

Income from all farm product sales in the study area has increased steadily over the past years, and is projected to continue into the future with an exception of the year 1980 (Table 16, page 60). The slight increase in 1980 farm income will result from the combination of crops grown in the Basin in 1980 and the change in prices from 1964. The 1980 allocation of crops is based on a partial restriction of efficiency through the incorporation of past trends into the economic budgeting model. For later years, the distribution results from an unrestricted efficiency allocation. The result is a different allocation of crops and acreages which, in turn, greatly affects the income from crop sales. The total value of farm products sold is projected to more than double from 1964 to 2020, when the total reaches 306 million dollars.

Sales of livestock and livestock products is projected to steadily increase during the study period. This will result in a steady upward trend in income from this source. Livestock sales consistently comprise the greater percentage of all farm product sales. The proportion of total farm income obtained from livestock and livestock products is projected to rise from 58 percent in 1954 to a high of about 66 percent by 1980, due to the decline in crop sales explained above. In 2020 livestock sales are expected to comprise about 61

TABLE 15 - Farm Income by Source of Sales for 1960, and Projections of Future Prices and Percentage Sales

Grand River Basin Study Area[1], Michigan

Commodity	Unit	1960 Production (1,000)	1960 Sold (percent)	1960 Units Sold (1,000)	1960 Price[2] (dollars)	1960 Value ($1,000)	[3]Proportion Future Prices 1980 (dollars)	[3]Proportion Future of Commodity Sold 1980 (percent)	2000 (percent)	2020 (percent)
Wheat	bu.	8,194.8	100	8,194.8	1.75	14,340.9	1.24	100	100	100
Corn	bu.	19,432.8	30	5,829.8	1.05	6,121.3	1.06	25	30	35
Oats	bu.	6,979.8	5	349.0	.65	226.9	.58	5	5	5
Barley	bu.	787.6	10	78.8	.80	63.0	.79	10	10	10
Soybeans	bu.	742.1	100	742.1	1.97	1,461.9	2.43	100	100	100
Dry Beans	cwt.	1,126.3	100	1,126.3	5.60	6,307.3	6.02	100	100	100
Potatoes	cwt.	1,538.5	100	1,538.5	2.31	3,553.9	1.97	100	100	100
Corn Silage	ton	534.9	0	---	--	---	--	0	0	0
Alfalfa Hay	ton	485.4	15	72.8	20.00	1,456.0	22.08	10	10	10
Other Hay	ton	125.1	10	12.5	17.00	212.5	19.20	5	5	5
Crop Pasture	aud	14,480.2	0	--	--	--	--	0	0	0
Vegetables	ton	91.9	100	91.9	63.39	5,825.5	71.37	100	100	100
Fruit	ton	61.5	100	61.5	68.08	4,186.9	93.90	100	100	100
Small Fruit	ton	2.9	100	2.9	134.00	388.6	93.90	100	100	100
Total Crop Sales		--	--	--	--	44,144.7	--	--	--	--
Beef and Veal	lb.	94,490.9	100	94,490.9	.210	19,843.1	.214	100	100	100
Lamb and Mutton	lb.	5,691.3	100	5,691.3	.170	967.5	.163	100	100	100
Pork	lb.	65,021.9	100	65,021.9	.143	9,298.1	.155	100	100	100
Chicken	lb.	13,182.8	100	13,182.8	.144	1,898.3	.147	100	100	100
Turkey	lb.	9,697.2	100	9,697.2	.222	2,152.8	.210	100	100	100
Milk	lb.	1,150,246.6	100	1,150,246.6	.040	46,009.9	.040	100	100	100
Eggs	lb.	29,003.3	100	29,003.3	.178	5,162.1	.198	100	100	100
Total Livestock Sales		--	--	--	--	85,331.8	--	--	--	--
Total Farm Sales		--	--	--	--	129,476.5	--	--	--	--

1/ Eleven County Study Area, Appendix O.

2/ Michigan Agricultural Statistics, 1964 prices.

3/ Price equals adjusted normalized United States price corrected for the ratio of Michigan prices to United States prices.

percent of all farm product sales.

TABLE 16 - Farm Income Derived from Sales of Commodities--Crops, Livestock and Livestock Products, and All Farm Products--for 1954, 1959, 1964 and Projections to 2020 1/

Grand River Basin, Michigan

Year	All Crops	Livestock and Livestock Products	All Farm Products
		(1,000 dollars)	
1954	43,131.4	58,395.2	101,526.6
1959	44,144.7	85,331.8	129,476.5
1964	67,206.8	83,987.8	151,194.6
1980	52,625.9	104,303.2	156,929.1
2000	81,764.8	156,957.8	238,722.6
2020	117,786.4	188,733.8	306,520.2

1/ Data for 1954, 1959, and 1964, U.S. Census of Agriculture, corrected to a hydrologic basis.

(2) Rural Farm Population

Rural farm population was projected to decrease by about 62 percent between 1960 and 2020 (Table 17, page 61). The great rates of decrease were expected to come in the earlier decades since both farm numbers and average size of farm family are decreasing. Rates of decrease after 2000, when average family size is assumed to stabilize, become about 13.9 percent, per decade (up to 2020), compared to rates of 11 to 26 percent for earlier periods (1960-2000).

Farms averaged 132 acres in 1960 and are projected to average more than 200 acres per farm by 2020. The average farm size is somewhat smaller than in most other nearby states, due to the large number of small holdings which, for definitional reasons, are classified as farms but produce only limited amounts of farm products. For instance, the 1959 Census of Agriculture indicates that average farm size in Illinois and Indiana was 196 acres and 145 acres respectively.

TABLE 17 - Rural-farm Population, All Farm Land, Numbers of Farms, and Average Farm Family Size for 1960, and Projections to 2020

Grand River Basin, Michigan

Year	Total Basin Farm Land 1/	Numbers of Farms	Average Farm Size	Average Farm Family Size	Rural-farm Population
	(1,000 Acres)	(1,000)	(Acres)	(Numbers)	(1,000 people)
1960	3,251.6	24.7	132	4.19	103.5
1970	2,922.7	19.8	148	3.87	76.6
1980	2,593.7	16.3	159	3.80	61.9
1990	2,545.8	14.7	173	3.70	54.4
2000	2,497.9	13.4	186	3.60	48.2
2010	2,442.4	12.1	202	3.60	43.6
2020	2,386.9	11.0	217	3.60	39.6

1/ Includes cropland, pasture, forest and others.

Basin farm numbers are expected to decrease by slightly more than 55 percent over the 60-year period. The decreases are expected to be in the medium size farms, as these farms are consolidated into larger, more efficient units. Farms in the larger size classes of more than 180 acres, are expected to increase in number.

(3) Rural Farm Employment

A downward trend in the farm employment percentage, which is reflected as a percent of total employment, has occurred between 1940 and 1960. Two factors are responsible for this trend: (1) the size of the total labor force is increasing; (2) the absolute size of farm labor numbers is decreasing. These interconnected and interrelated trends are projected to continue.

Projected total rural-farm labor requirements are projected to decrease by about 17 percent from 1960 to 2020 (Table 18, page 62). Over the same period the hired labor component also decreases, reflecting increased use of mechanization in growing, harvesting, and various specialized crop production techniques.

The average time worked per year for farm labor is expected to decline by nearly 33.5 percent from 1960 to 2020. Agricultural workers were assumed to have a work year approaching that of the private

TABLE 18 - Rural-farm Employment and Average Work Year for 1960, and Projections to 2020

Grand River Basin, Michigan

Year	Time Worked Per Year 1/	Rural-farm Labor Requirements		Agricultural Workers 2/
		Hired	Total	
	(hours)	(100 man years)		
1960	2,300	--	140.2	150.2
1970	2,212	13.5	137.4	147.4
1980	2,125	13.3	134.7	144.7
1990	2,062	11.8	134.1	144.1
2000	2,000	10.4	133.6	143.6
2010	1,950	10.1	124.8	134.8
2020	1,900	9.9	116.0	126.0

1/ National Economic Growth Projections, U.S. Department of Commerce, Office of Business Economics, Regional Economics Division, 1968, with interpolations for intervening decades.

2/ The difference of approximately 1,000 between total agricultural workers and rural-farm labor requirements represents professional and service employment oriented to the agricultural sector.

nonfarm sector of the economy by about 2020. However, the private nonfarm sector work year average was only 2,000 hours in 1960, some 300 hours less than the agricultural work year.

Off-farm work is likely to decrease somewhat as larger, more specialized farms provide more opportunity for full-time work. Part-time farming may continue to be prevalent in the future but to a lesser degree. In this case, the projected rural-farm population might be underestimated.

6. FORESTRY RESOURCES AND RELATED ECONOMIC ACTIVITY

Forested lands are principally located in the northern and western parts of the Basin. They mainly consist of hardwoods, primarily oaks and maples.

The forest industries make important contributions to the total Basin economy. The opportunity exists for the forested areas to be instrumental in meeting the future demands for more timber products and recreational areas. Improved management through proper land use and treatment will help the owners of the forested lands meet the future total land use needs of the people and the industry.

a. Extent and Nature of the Resources Over 536,000 acres in the Basin are in forested land. There is nearly a half billion cubic feet of merchantable wood in growing stock. The quality of this timber is expected to determine the ultimate market values of future tree crops.

(1) Forested Land

Of the 3.5 million acres of land in the Basin, approximately 15 percent is forested land of which 94 percent is privately owned (Table 19, page 64). More than 99 percent of it, nearly 532,000 acres, is classed as commercial forest land--that is, land suitable and available for growing continuous crops of sawlogs or other industrial forest products. Included in the acreage of forested lands are those many smaller areas of only a few acres generally referred to as woodlands. They may be associated with farms, such as farm wood lots; with cities and towns, such as in parks and recreation areas; or with recent suburban developments, particularly those remnants of the forested areas which are left following the conversion of most of the woodland into home sites. These small woodlands occur on sites that vary

from rich loamy soils of high agricultural productivity to very poor, sandy soils having considerably less agricultural potential.

TABIE 19 - Area of Forest Land by Ownership, January 1, 1963
Grand River Basin, Michigan

Total Forest Land	Noncommercial	Commerical Forest Land			
		Total	National Forest	Other Public	Private
		(1,000 acres)			
536.2	4.5	531.7	0.4	34.5	496.8

Source: Adapted from "Timber Resources in Michigan's Grand River Basin", Forest Service, USDA, June 1966.

Approximately 4,500 acres in the Basin are classed as noncommercial forest land. This includes forested land that is either unsuited for timber growth because of low productivity or legally reserved for recreation and other non-timber uses. Some of this noncommercial forest acreage includes small woodlands.

(2) Timber Inventory

The amount of merchantable wood in growing stock trees totals about 471 million cubic feet (Table 20, page 66). The growing stock volume averages 885 cubic feet of wood per acre of trees. This wood represents both the base for future growth and a reservoir of standing logs from which industries may draw to fill their needs. Almost all growing stock is hardwood, and over half is in sawtimber-sized trees -- trees over 11 inches in diameter at breast height, and sufficiently straight and sound to contain at least one 12-foot sawlog. Poletimber-sized trees, by contrast, are 5.0 to 8.9 inches in diameter at breast height for softwood, and 5.0 to 10.9 inches (DBH) for hardwoods.

Hardwoods comprise nearly all of the sawtimber volume, approximately 1.42 billion board feet as measured by the International $\frac{1}{4}$-inch rule. Eighty-five percent of this volume is found in sawtimber stands.

Growing stock volume is measured in cubic feet, while sawtimber volume is commonly measured in board feet. A board foot unit equals 1/12th of a cubic foot and represents wood cut 1 inch thick, by

12 inches wide, and 12 inches long. Growing stock volume considers the total amount of sound wood in the trunks of trees 5 inches or more in diameter at breast height. Sawtimber volume includes the amount of wood in a 12-foot or longer sawlog obtainable from hardwood trees with 11-inch or more diameters and from softwood trees with 9-inch or more diameters. For a rough conversion factor, there are approximately five board feet in one cubic foot; however, this is a variable ratio.

Of the total sawtimber volume, 29 percent is select white and red oak, and 10 percent hard maple (Figure 3, page 67). About 3 percent is softwood sawtimber volume -- largely pine. The 52 percent of other hardwoods includes beech, the elms, and soft maples.

Figure 4 (page 67) shows the acreage of commercial forest land by stand-size classes. Sawtimber stands occur on 40 percent of this forested land.

(3) Timber Quality

Figures on timber resource volume alone are not enough to adequately appraise the available timber supply. Consideration of timber quality is also very important in determining the competitive strength of the timber industries.

Log grades are an indication of the relative quality of the sawtimber material; the lowest grade number has the highest sawtimber value. A Forest Survey of this area compiled in 1963 indicated 12 percent of the sawtimber volume to be Grade 1 logs, 29 percent to be Grade 2 logs, and 59 percent to be Grade 3 logs or tie and timber materials (Table 21, page 68). Thirty-seven percent of the select white and red oak sawtimber volume was in Grades 1 and 2.

Timber size is a very significan factor in determining log grade. Few trees less than 15 inches in diameter a breast height contain Grade 1 or 2 logs. In the Basin, 43 percent of the sawtimber volume was in trees less than 15 inches in diameter (Table 22, page 69). Only 26 percent of the sawtimber volume of hardwoods was in trees 19 inches in diameter or larger. Fifty-one percent of the sawtimber volume classified as select white and red oaks was in trees less than 15 inches in diameter, while 37 percent of the hard maple sawtimber volume

TABLE 20 - Volume of Growing Stock and Sawtimber on Commercial Forest Land by Species and Stand-size Classes, January 1, 1963

Grand River Basin, Michigan

Species	Growing Stock			Sawtimber		
	Poletimber	Sawtimber	Total	In Sawtimber Stands	In Other Stands	Total
	(million cubic feet)			(million board feet)		
Hardwoods:						
Select white and red oaks	63.1	74.4	137.5	350.4	55.1	405.5
Hickory	4.6	3.1	7.7	14.3	2.0	16.3
Yellow birch	1.6	.4	2.0	1.3	.5	1.8
Hard maple	14.1	26.9	41.0	136.8	10.9	147.7
Ash and black cherry	16.4	10.7	27.1	53.5	5.3	58.5
Cottonwood and aspen	17.0	4.8	21.8	18.9	6.2	25.1
Other hardwoods	87.4	133.0	220.4	607.6	115.6	723.2
Total	204.2	253.3	457.5	1,182.8	195.6	1,378.4
Softwoods:						
Pine	2.0	6.3	8.3	16.9	12.6	29.5
Spruce and balsam fir	2.1	2.5	4.6	6.6	4.4	11.0
Other	.1	.1	.2		.1	
Total	4.2	8.9	13.1	23.5	17.1	40.6
GRAND TOTAL	208.4	262.2	470.6	1,206.3	212.7	1,419.0

Source: Adapted from "Timber Resources in Michigan's Grand River Basin", Forest Service, USDA, June 1966.

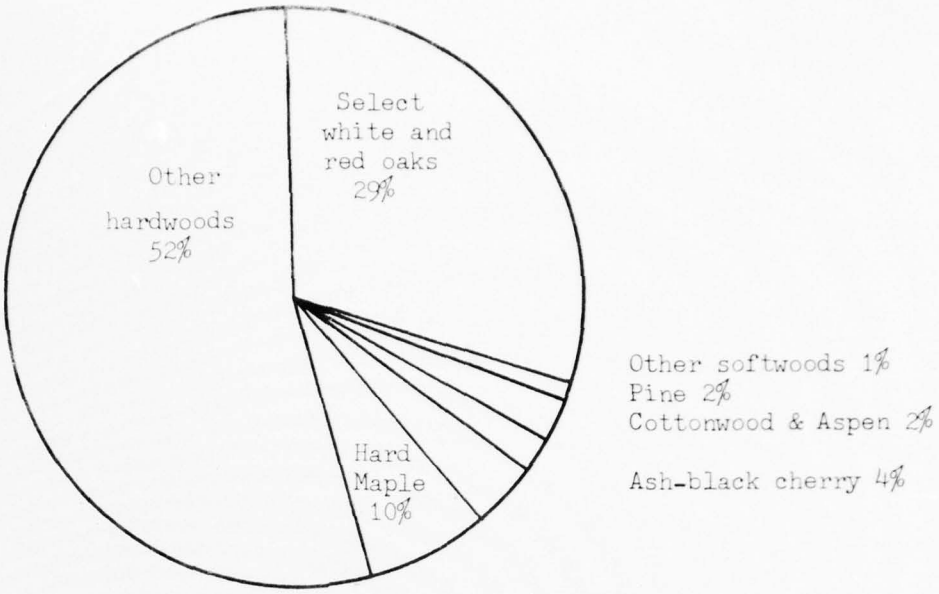

Figure 3 - Distribution of Sawtimber Volume by Species or Species Group, 1963 Grand River Basin, Michigan

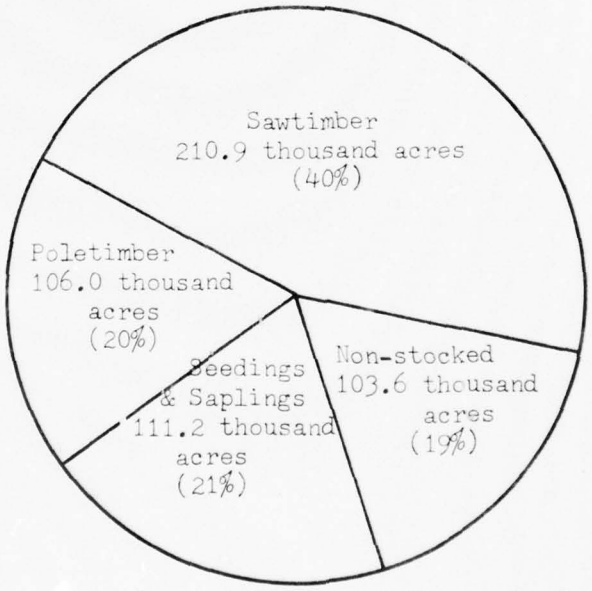

Figure 4 - Area of Commercial Forest Land by Stand-size Classes,, 1963. Grand River Basin, Michigan

TABLE 21 - Volume of Hardwood Sawtimber on Commercial Forest Land
by Species and Log Grades, January 1, 1963
Grand River Basin, Michigan

Species	Log Grades			
	Number 1	Number 2	Number 3 and tie and timber	Total
	(Million Board Feet)			
Select white and red oaks	61.6	89.1	254.8	405.5
Hickory	3.8	1.3	11.2	16.3
Yellow birch	.4	.6	.8	1.8
Hard maple	22.1	53.2	72.4	147.7
Ash and black cherry	11.9	15.6	31.3	58.8
Cottonwood and aspen	2.5	5.5	17.1	25.1
Other hardwoods	66.9	233.2	423.1	723.2
Total	169.2	398.5	810.7	1,378.4

Source: Adapted from "Timber Resources in Michigan's Grand River Basin," Forest Service, USDA, June 1966.

TABLE 22 - Volume of Sawtimber on Commercial Forest Land
by Species and Diameter Classes, January 1, 1963
Grand River Basin, Michigan

Species	Diameter Classes (inches)			
	Less Than 15.0 1/	15.0 - 19.0	19.0 -29.0	Total
	(Million board feet)			
Hardwoods:				
Select white and red oaks	207.1	130.3	68.1	405.5
Hickory	11.8	3.2	1.3	16.3
Yellow birch	1.1	.7	-	1.8
Hard Maple	54.7	51.0	42.0	147.7
Ash and black cherry	30.7	20.4	7.7	58.8
Cottonwood and aspen	8.6	3.4	13.1	25.1
Other hardwoods	271.6	225.0	226.6	723.2
Total	585.6	434.0	358.8	1,378.4
Softwoods:				
Pine	16.5	10.1	2.9	29.5
Spruce and balsam fir	.1	-	-	.1
Other softwoods	6.9	3.1	1.0	11.0
Total	23.5	13.2	3.9	40.6
GRAND TOTAL	609.1	447.2	362.7	1,419.0

1/ Hardwood diameters from 11.0 to 15.0 and softwood diameters from 9.0 to 15.0 inches at breast height.

Source: Adapted from "Timber Resources in Michigan's Grand River Basin," Forest Service, USDA, June 1966.

TABLE 23 - Net Annual Growth of Growing Stock and Sawtimber on Commercial Forest Land by Species, 1962

Grand River Basin, Michigan

Species	Growing Stock	Sawtimber
	(1000 cubic ft.)	(1000 board ft.)
Hardwoods:		
Select white and red oaks	4,085	13,869
Hickory	228	555
Yellow birch	58	62
Hard maple	1,219	5,052
Ash and black cherry	806	2,009
Cottonwood and aspen	648	858
Other hardwoods	6,548	24,735
Subtotal	13,592	47,140
Softwoods:		
Pine	356	1,524
Spruce and balsam fir	7	4
Other softwoods	201	572
Subtotal	564	2,100
TOTAL	14,156	49,240

Source: Adapted form "Timber Resources in Michigan's Grand River Basin", Forest Service, USDA, June 1966.

TABLE 24 - Timber Cut, Growth, and Inventory of Growing Stock on Commercial Forest Land for 1952 and 1962, and Projections, 1980-2020

Grand River Basin, Michigan

Year	Cut			Growth			Inventory		
	Soft-woods	Hard-woods	All Species	Soft-woods	Hard-woods	All Species	Soft-woods	Hard-woods	All Species
	(Million cubic feet)								
1952	0.1	6.9	7.0	0.4	12.4	12.8	9.2	376.0	385.2 1/
1962	0.1	5.5	5.6	0.6	13.6	14.2	13.1	475.5	470.6 1/
	Projections								
1980	0.2	6.8	7.0	0.8	13.9	14.7	20.1	571.9	592.0
2000	0.2	9.6	9.8	1.0	14.3	15.3	31.6	677.3	708.9
2020	0.3	12.5	12.8	1.2	14.6	15.8	46.7	726.3	773.0

1/ As of January 1, 1953 and 1963

Source: Adapted from "Timber Resources in Michigan's Grand River Basin", Forest Service, USDA, June 1966.

TABLE 25 - Timber Cut, Growth, and Inventory of Sawtimber on Commercial Forest Land for 1952 and 1962, and Projections, 1980-2020
Grand River Basin, Michigan

Year	Cut			Growth			Inventory		
	Soft-woods	Hard-woods	All Species	Soft-woods	Hard-woods	All Species	Soft-woods	Hard-woods	All Species
	(million board feet)								
1952	0.4	20.1	20.5	1.7	42.9	44.6	30.0	1,131.1	1,161.1 1/
1962	0.3	16.0	16.3	2.1	47.1	49.2	40.6	1,378.4	1,419.0 1/
	Projections								
1980	0.5	19.9	20.4	2.4	54.9	57.3	58.6	1,660.2	1,718.8
2000	0.6	28.1	28.7	4.1	69.2	73.3	103.3	2,071.7	2,175.0
2020	0.7	37.2	37.9	6.2	78.0	84.2	182.1	2,396.5	2,578.6

1/ As of January 1, 1953 and 1963

Source: Adapted from "Timber Resources in Michigan's Grand River Basin", Forest Service, USDA June 1966.

was in trees less than 15 inches in diameter.

b. Present and Projected Growth, Cut, and Inventory The Grand River Basin is an area of predominantly fertile soils and a long-growing season (for a northern state), and it can produce high quality trees.

(1) Present Timber Growth and Cut

Net timber growth provides a rough indication of the amount of timber which may be cut. It is used along with other indices to calculate the allowable yearly cut with sustained yield management as the objective.

The net annual growth of all growing stock is estimated to be 14.2 million cubic feet. This represents 3 percent of the total growing stock volume (Table 20, page 66, and Table 23, page 70). Net annual growth of sawtimber for the Basin in 1962 was estimated to be 49.2 million board feet, or nearly 4 percent of the total sawtimber volume. Select white and red oaks lead in growth with hard maple ranking second.

The net annual growth per acre averages 27 cubic feet of growing stock which includes 17 cubic feet of sawtimber. The state average in 1965 was 30.7 cubic feet. This relatively low current growth reflects, in part, a limited stocking resulting from past cutting, grazing, fire, and tree mortality. In 1965 mortality was equal to approximately 30 percent of the gross growth of growing stock in Michigan. The principal cause of mortality in the Basin is Dutch Elm disease. A large amount of growing space is now occupied by brush or undersirable tree species that restrict growth of desirable trees. Many stands are too young to include sawtimber trees, and some are on relatively poor sites. There are, however, areas of young forests on the threshold of entering the sawtimber-sized class. As these stands mature, sawtimber growth may be expected to increase.

The amount of timber cut from the total growing stock in the Grand River Basin in 1962 amounted to 5.6 million cubic feet. (Table 24, page 71). The volume of sawtimber cut that year was approximately 16.3 million board feet, International $\frac{1}{4}$-inch role, as compared to an annual growth of 49.2 million board feet, (Table 25, page 72). Select white and red oaks and hard maple were the most heavily cut species.

TABLE 26 - Timber Cut from Growing Stock and Sawtimber on Commercial Forest Land by Species, 1962
Grand River Basin, Michigan

Species	Growing Stock (1000 cubic feet)	Sawtimber (1000 board feet)
Hardwoods:		
Select white and red oaks	1,698	5,583
Hickory	8	15
Yellow Birch	60	173
Hard maple	864	2,404
Ash and black cherry	98	353
Cottonwood and aspen	496	849
Other hardwoods	2,262	6,627
Subtotal	5,486	16,004
Softwoods:		
Pine	60	248
Spruce and balsam fir	-	-
Other softwoods	15	53
Subtotal	75	301
TOTAL	5,561	16,305

Source: Adapted from "Timber Resources in Michigan's Grand River Basin," Forest Service, USDA, June 1966.

Sixty-six percent of the hardwood sawtimber growth and eighty-six percent of the softwood sawtimber growth are not cut. This excess of growth over cut is partly the result of improved fire protection in recent decades, an extensive tree planting program, and recent reductions in timber harvesting. This current situation does not, however, represent an immediate opportunity for a general increase in cutting. Growth is now occuring mainly in smaller trees; the larger trees, sought by industry, are becoming more difficult to locate. About 54 percent of the current hardwood sawtimber growth is concentrated among less desirable species (Table 23). The sawtimber cut from these species makes up only 40 percent of the actual cut (Table 26, page 74). The less desirable species and cull trees not being cut are occupying or encroaching on sites suitable for preferred hardwoods.

(2) Trend in Cut, Growth, and Inventory

Net annual growth of all species is expected to increase from 14.2 million cubic feet in 1962 to about 15.8 million cubic feet by 2020 (Table 24, page 71, and Table 25, page 72). Similarly, the net annual growth of sawtimber of all species is expected to increase from 49.2 million board feet in 1962 to 84.2 million board feet in the year 2020. More than nine-tenths of the sawtimber produced until 2020 will be hardwood species.

The annual timber cut of all species in the Grand River Basin showed a decline from 1952 to 1962 in both cubic feet and board feet volumes. Projections indicate that this trend will reverse. The total projected cut of all species will be approximately 12.8 million cubic feet by the year 2020. This is a much larger rate of increase than of growth. By 2020, cut is expected to be about four-fifths of the growth of all growing stock.

Similarly, the sawtimber cut from all species, which declined between 1952 and 1962, is expected to increase. This cut is expected to rise from about 16.3 million board feet in 1962 to about 38 million board feet by the year 2020. Since the cut in 2020 is only 45 percent of the growth of all species, additional large cuts of sawtimber will be desirable thereafter as timber-size, quality, and the market situation warrant expansion.

Since cut is less than growth, both growing stock and sawtimber inventories should rise. The inventories found in 1952 should double by the year 2020. After the year 2000 the rate of increase of inventory diminishes as cut draws closer to growth.

c. Present and Projected Use of the Resource Use of the resource will be considered in terms of timber products output from a Basin-wide viewpoint and will include these output factors: type, volume, and value. All of them are tied in with the future use of the forested lands.

(1) Type and Volume of Output

In recent years, the output of saw logs and veneer logs made up the greater part of the timber products of the Basin, with minor industrial products, pulpwood, and fuelwood being of lesser importance. Between 1952 and 1962, the output of saw logs, veneer logs, and minor industrial products decreased nearly one-third, due in part to the inadequate supply of large, high quality sawtimber and partly to increased competition from other areas (Table 27, page 78). The output of round pulpwood is expected to increase from 8,000 cords in 1962 to about 26,000 cords in the year 2020. Fuelwood output is expected to continue to decline from about 42,000 cords of roundwood in 1962 to 15,000 cords in the year 2020. The 1952 to 1962 decline in the output of saw logs, veneer logs, and minor industrial products is expected to be reversed, with output to increase from 3.5 million cubic feet in 1962 to 9.6 million cubic feet by the year 2020.

(2) Value of Output

The stumpage value of the standing timber from which the 1962 forest products were cut was about $340,000. The value added after harvesting the rough, round forest products was $1,462,000 at local points of delivery. This represents wages and profits to forest and woodland owners and to those people engaged in harvesting and delivering these products. This is only a portion of the total value added of forest products in the Basin. The other added values in forest-based economic activities such as primary manufacturing, secondary manufacturing, construction, transportation, and marketing are found in Table 28, page 79 .

By the year 2020, the stumpage value of the forest products cut is projected to be more than double the 1962 value. The total value added from all kinds of forest-based economic activities in 2020 will be over $59 million, more than double that in 1962.

(3) Trends in Resource Use

One of the most important changes in land use that has happened in recent years -- and is projected to continue in future years -- is the reduction in number of farms and the acreage in farmland. Part of the agricultural land going into retirement is expected to revert to forest cover, either through planting or natural seeding. In addition, lesser amounts of existing forest land will be cleared for agricultural production.

There will, however, be increased pressure to convert existing forested land to nonagricultural uses, including specialized recreation and various forms of urban development such as housing, highway, and airport construction. Though these uses are generally essential, they will replace some of the purely forestry uses, thus cutting down on the potential future volume of timber production.

The growing popularity of outdoor recreation has increased the demand for such recreational facilities on forested lands and park sites, public fishing access areas, and picnicking and camping grounds. The future may see a great deal of recreation land use development in the small private woodlands which may stimulate some setting aside of parts of the larger, commercial forest land for woodland-oriented recreation uses.

Much of this forest land conversion to nonagricultural uses will be taking place in the urban-rural fringe as cities and towns expand into the surrounding countyside. Besides taking forest land out of production, the conversion serves to isolate certain sections from timber product markets (Figure 5, page 80). This lack of reasonable access to these stranded pockets of forest land lowers their value as effective sources of timber.

TABLE 27 - Timber Products Output for 1952 and 1962,
and Projections, 1980-2020
Grand River Basin, Michigan

Year	Saw logs, veneer logs, and minor Industrial products 1/	Pulpwood			Fuelwood		
		Round-wood	Plant by-Products	Total	Round-wood	Plant by-Products	Total
	(thousand cubic feet)	(thousand cords) 2/			(thousand cords) 2/		
1952	5,100	4	--	4	75	19	94
1962	3,500	8	--	8	42	11	53
			Projections				
1980	4,000	15	4	19	22	8	30
2000	6,600	18	8	26	22	4	26
2020	9,600	26	12	38	15	4	19

1/ Minor industrial products include cooperage logs, poles, piling, mine timbers, posts, chemical wood, box bolts, and a miscellaneous assortment of similar items.

2/ Standard survey cord of 79 cubic feet of solid wood.

Source: Adapted from "Timber Resources in Michigan's Grand River Basin", Forest Service, USDA, June 1966.

TABLE 28 - Estimated Value Added in Timber-based Economic Activities by Industry for 1952, 1962 and Projections to 2020 Grand River Basin, Michigan

Year	1/ Forest Management	2/ Harvesting	Primary Manufacturing	Secondary Manufacturing	Construction	Transportation and Marketing	3/ Total
				($1,000)			
1952	560	2,408	4,144	7,784	14,000	8,400	37,296
1962	340	1,462	3,502	5,848	8,840	6,222	26,214
1980	420	1,806	4,326	7,224	10,920	7,686	32,382
2000	588	2,528	6,056	10,114	15,288	10,760	45,334
2020	768	3,302	7,910	13,210	19,968	14,054	59,212

1/ Based on 1958 dollar value of stumpage cut and given yearly volume of cut. Assumed value of stumpage cut equalled value added in forest management.

2/ To local points of delivery.

3/ Based on 1958 value added in timber-based economic activities in Michigan.

Source: Adapted from "The Economic Importance of Timber in the U.S.," Misc. Publication 941, Forest Service, USDA, 1963.

KENT COUNTY, MICHIGAN

1955 1960

FIGURE 5. — Rural land use changes in Michigan are often quite subtle. But there are times when the rural terrain is modified to a considerable extent. These two aerial photos, taken of approximately the same area at a 5-year interval, demonstrate how highway construction can greatly modify forest land. One woodlot shown (X) has been so dissected that it may never again support a timber harvest. (Photo courtesy U.S. Agricultural Stabilization and Conservation Service.)

Source: Sullivan, Jon M., Forest owners and timber management in Michigan. Lake States Forest Experiment Station, St. Paul, Minn. (U.S. Forest Service Res. Paper LS-93).

S,L-23714

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GRAND RIVER BASIN MICHIGAN. COMPREHENSIVE WATER RESOURCES STUDY--ETC(U)
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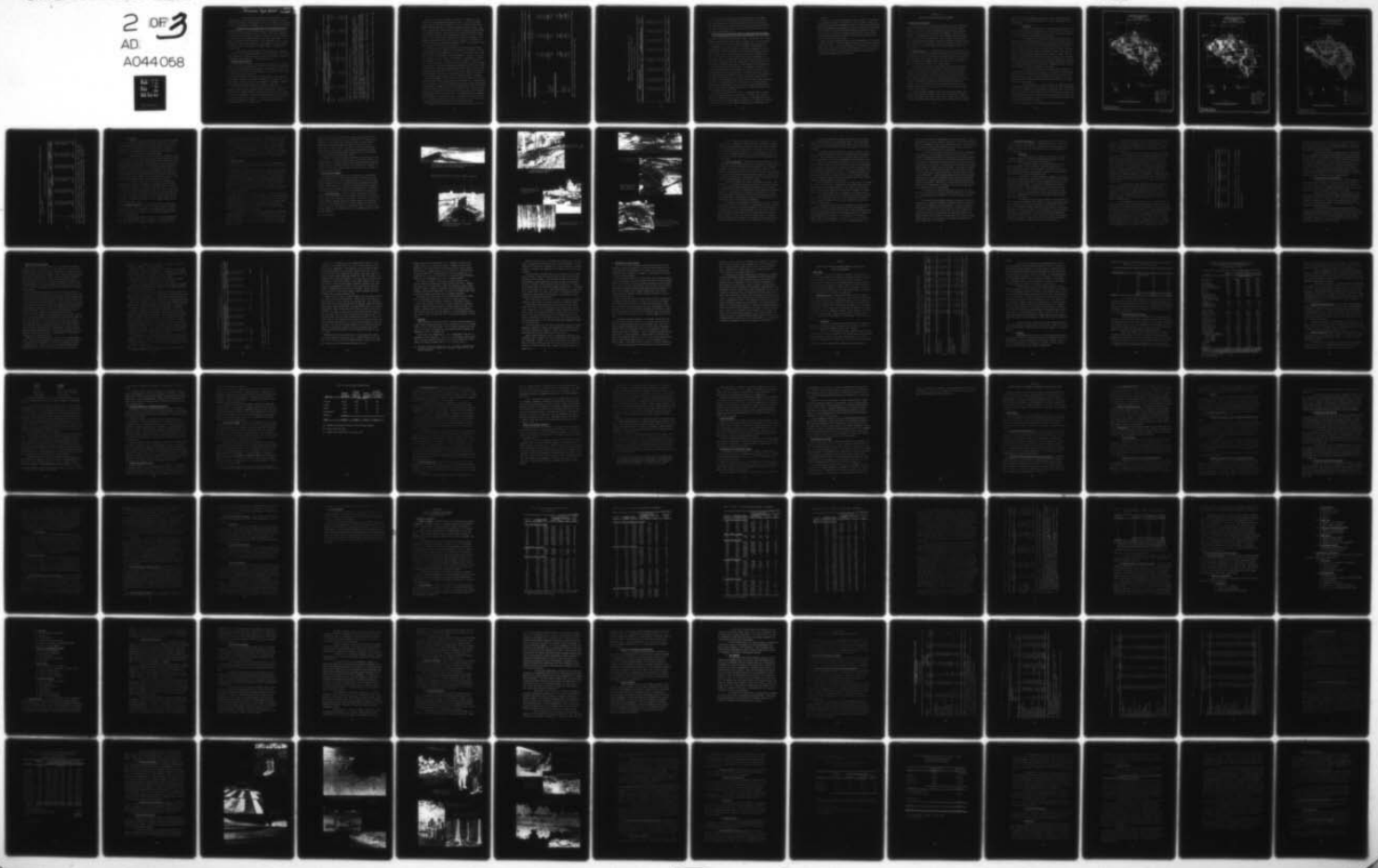

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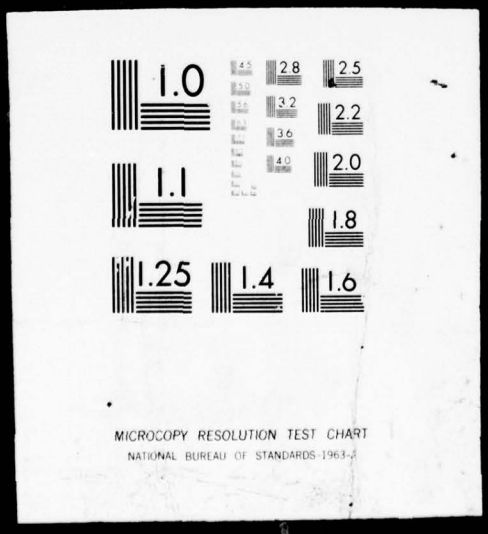


Farm woodlots, bottomlands, and other areas now in saw-timber-size trees will bear the brunt of the future demand for additional land use conversion. Replenishment of this lost timber with new plantings cannot be produced in a decade or two, but is a long-term proposition.

d. Present and Projected Employment in Forest-Based Industries

Esimated employment in the Grand River Basin in forest-based industries dropped from 3,250 employees in 1952 to 2,540 in 1962, but is expected to rise to 6,230 by the year 2020 (Table 29, page 82). These estimates are based upon the anticipated timber cut, and upon improvements in the output per man-day. Over five-sixths of this employment will be in the manufacture of forest-based products. This manufacture of pulp, paper and allied products will require the largest number of employees up to the year 2000.

Although the future demand for forest products is expected to be greater, the comparatively small size and low quality of the trees, plus the decrease in manpower wanting to work in forest-based industries is expected to delay expansion of harvesting operations.

7. NONAGRICULTURAL LAND USE

In recent years conversions of land from crop, pasture, and forestry uses to such nonagricultural uses as residential, industrial, commercial, recreation, and transportation development have markedly increased. Use of rural lands for urban-industrial expansion and recreation will become more commonplace by the year 2020.

Lands not presently being used for crops, pasture, or woodland comprise nearly 23 percent of the Basin acreage (Table 10, page 48). Acreage devoted to nonagricultural use is projected to increase to nearly 29 percent during the 60-year study period (Table 11, page 50).

Of the 785,250 acres classed as nonagricultural land in 1958, over 35 percent, or 279,700 acres, comprised urban built-up areas. These included the vast roadway systems as well as housing and business construction sites. Land devoted to urban and industrial expansion is projected to more than double by the year 2020. This projected estimate of 591,400 acres would be more than 58 percent of the total projected acreage in nonagricultural uses for the year 2020.

TABLE 29 - Estimated Total Employment in Timber Based Manufacturing Industries for 1952 and 1962, and Projections, 1980-2020

Grand River Basin, Michigan

Year	Primary manufacture of timber products				Timber Harvesting 4/	Total
	Sawmills and Planning mills 1/	Other 2/	Pulp, paper and Allied products 3/	Total		
	(Number of Employees)					
1952	300	1,100	1,100	2,500	750	3,250
1962	250	700	1,100	2,050	490	2,540
			Projections			
1980	300	1,000	1,500	2,800	450	3,250
2000	450	1,600	1,900	3,950	640	4,590
2020	700	2,400	2,300	5,400	830	6,230

1/ Sawmills, planning mills, dimension and flooring mills, etc.

2/ Veneer mills, shingle mills, cooperage stock mills, plywood mills engaged in producing wood basic materials and establishments engaged in manufacturing finished articles made entirely or mainly of wood. (1/, 2/ and 4/ together make up major group 24 as defined by the Bureau of Census).

3/ Includes establishments manufacturing pulp primarily from wood from rags and other fibers, converting these pulps into paper or board; and the manufacture of paper and paperboard into converted products such as coated paper, paper bags, paper boxes and envelopes. (Major group 26 as defined by the the Bureau of the Census.)

4/ Production or rough forest products i.e. -- sawlogs, pulpwood, etc. Include operations through delivery of logs by truck to mill or f.o.b. railroad car.

Source: Adapted from "Timber Resources in Michigan's Grand River Basin", Forest Service, USDA, June 1966.

Recreational use of all lands is projected to increase at a rate greater than anticipated Basin population growth. Basin lands support camping, picnicking, skiing, golfing, hunting, and vacation farm sites. Water areas provide boating, swimming, and fishing opportunities. Some present agricultural lands will be converted to handle the greater demand for recreational space. But the bulk of the future recreational activities will take place as part of multiple-use programs on crop and forest lands. This is particularly true with another form of recreation -- the aesthetic appreciation of the out-of-doors. Enjoyment of nature's resources as they are provides and intangible benefit of incalculable therapeutic value to the human mind and senses.

Projected land use changes associated with urban-industrial expansion were based on past trends and future population assumptions. Michigan's population was projected to continue to grow at the national growth rate. In 1960, the population was approximately 1.1 million in the economic study area of 11 counties. The population is projected to increase to 1.5 million in 1980, 2.1 million in 2000, and nearly 2.9 million by 2020. The availability of future resources was based on projected changes in population and historical relationships between urban land use and population changes. Estimates of likely agricultural soils for future urban-related uses were made for the CNI in each county. These soil relationships were applied to the total urban-related land needs and converted to crop and pasture land acreages (Table 30, page 84; Table 31, page 85).

The base acreage of cropland was reduced by three percent in 1980 to account for the 49,000 acres projected to be shifting into nonagricultural uses. A reduction of 232,000 cropland acres over the 60-year study period is projected, 12 percent of the 1958 CNI cropland base. The rate at which cropland acreage is reduced over the study period is not constant for two reasons: (1) the addition of new people to the population base increases more rapidly as 2020 is approached, and (2) the availability of permanent pasture which can be easily and cheaply developed for urban and related uses is assumed to decrease over time. This explains the downward trend in pasture acreage removed from the agricultural land base.

The needs of the Basin population will ultimately direct the extent

TABLE 30 - Acreages of Cropland and Pasture by Soil Associations, 1958

Grand River Basin, Michigan

Soil Associations	Current Use		
	Cropland	Pasture	Total
		(1,000 Acres)	
Suited for Crop Production			
1	49.7	4.7	54.4
2	721.9	98.9	820.8
3	170.5	18.6	189.1
4	569.4	64.3	633.7
7	72.7	40.0	112.7
Subtotal	1,584.2	226.5	1,810.7
Percent	87.5	12.5	100.0
Suited for Pasture Production			
5	269.8	58.8	328.6
6	85.9	11.6	97.5
Subtotal	355.7	70.4	426.1
Percent	83.5	16.5	100.0
TOTAL	1,939.9	269.9	2,236.8

Source: Inventory of Michigan Soil and Water Conservation Needs, 1962.

TABLE 31 - Expected Urban and Industrial Impact on the Agricultural Resource Base by Projection Periods 1/
Grand River Basin, Michigan

Soil Associations	Reduction in Cropland 1960-1980	1981-2000	2001-2020	Total by 2020	Reduction in Pasture 1960-1980	1981-2000	2001-2020	Total by 2020
1	.9	1.5	2.2	4.6	.6	.7	.7	2.0
2	19.3	29.1	43.6	92.0	9.6	9.2	9.3	28.1
3	4.0	6.2	9.2	19.4	2.6	2.4	2.4	7.4
4	13.8	20.3	30.9	65.0	7.5	6.8	6.9	21.2
5	6.9	10.0	15.5	32.4	4.7	4.3	4.4	13.4
6	2.2	3.3	5.3	10.8	1.3	1.4	1.4	4.1
7	2.0	2.7	3.9	8.6	.8	.8	.8	2.4
Total	49.1	73.1	110.6	232.8	27.1	25.6	25.9	78.6

1/ Economic base study, Appendix O.

of conversion from agricultural to nonagricultural land use. Demand for more recreation and urban-industrial land will drive the value of such lands upwards where particularly suited for these nonagricultural uses. When the value of and the profit derived from such nonagricultural uses becomes substantially more attractive than from agricultural uses, the shift in useage will occur.

8. RELATIONSHIP OF ECONOMIC DEVELOPMENT AND WATER RESOURCE DEVELOPMENT

Economic development causes certain general effects upon the economic environment, both inside and outside the Basin. The degree of this effect lessens as the distance from the Basin increases, but it is more strongly influenced by the kind of economic development taking place nearby.

Development of the water resources influences the development of associated land resources as well as other economic endeavors in and out of the Basin. Initial investments in an economic development by public and/or private sources typically stimulate additional investments, by one or both sources, to either improve the initial developments ot to compete with them. The improvement investments may be reflected in added services or expanded production capabilities. Many investments are also made to encourage development of complimentary economic enterprises.

Although water resource development is basically the correction or alleviation of a water-related problem, the solutions may allow and encourage additional economic prosperity. During the construction phase of a water resource development project, the construction, transportation, and material supplying sectors of the economy are the immediate beneficiaries. Once completed, many other sections of the economy can achieve benefits. One example might be the elimination of a wetness problem through channel improvement; this then allows a group of farmers affected to install proper drainage systems that will help them increase their total production and yield rates.

The additional production may result in increased sales to product user. The added sales may be re-invested in the farm, hence more construction, transportation, and utility inputs. Or they may benefit the household sector with higher wages and salaries. As incomes rise, expenditures for food, clothing, housing, transportation, entertainment also

increase.

This growth of the economy through production expansion is dependent upon an adequate product use. Without a sufficient market demand, the purchases of inputs and the sales of products to related economic sectors would not represent an economic gain to society. The bulk of the buying and selling would shift from the less efficient producers to the more efficient ones. And without a dynamic market demand, a static market could result with simply a transfer of economic activity among firms with off-setting gains and losses.

Water resources development and economic development are not readily separable entities. The above example indicates how water resource development contricutes to economic development but the reverse is also true. Frequently the need for water resource development is a direct result of economic development that has created a problem that needs correction before further development can take place.

SECTION IV

WATER AND RELATED LAND RESOURCE PROBLEMS

1. WATER SUPPLY AVAILABILITY

The total water supply is plentiful, but still is a scarce resource in terms of availability at the proper time or place, and in the required amounts. An adequate supply and distribution of high quality water is a problem in some areas, and will become more critical as future demands increase. The agricultural and forest plant and animal life are in competition with many nonagricultural uses and activities for the available surface and ground water. Present use patterns indicate inefficiencies and waste which need to be corrected. Multiple use and reuse of water may result in serious water quality problems if better management methods are not adopted.

a. Agricultural Use The availability of land for agricultural uses is declining, yet the public demand for agricultural products is increasing. The proper use of the water available for agricultural production will become increasingly more important during the study period. The problem of water availability, as ground, surface and rainfall, is most critical during the droughtiest period of the growing season.

The problem of farm water supply systems for livestock and domestic household use is often one of economics. Where wells cannot be developed at a reasonable cost, surface water supply systems are often utilized to fill the need. In general, surface water systems are not as satisfactory for domestic use as are ground water supplies from wells. Surface water supplies nearly always need sanitation treatment to be made potable. In addition, the quality of surface water can change very quickly. Changes in vegetation in the watershed from one year or one season to the next can have a great effect on the water treatment needs of surface water supply.

Varying climatic conditions within the Basin create diverse agricultural water management problems, i.e., the distributional patterns of rainfall and natural stream flow. Even in high rainfall areas, there are shortages of precipitation during portions of the growing season. Though

many of these streams reach flood proportions during the spring, water flows later in the summer are insufficient to support irrigation of any significance.

(1) Irrigation

Sources for irrigation water supply are surface water and ground water. Ground water supplies are usually from wells, although many pit ponds are recharged mainly from ground water. Surface water supplies come from natural lakes, impoundments, and channels.

All irrigation is the sprinkler type and is usually done on the organic and coarser mineral soils. The major portion of the land irrigated is devoted to truck crops, fruit, and potatoes. Such irrigation is not currently in heavy use in the Basin for these crops, but is expected to increase on them as well as on field and sod crops. There were 21,167 acres[1/] irrigated in 1964 which, during an average season, represents an estimated pumped volume of 11,370 acre-feet of water. This includes some nonagricultural irrigation for golf courses, parks, and cemeteries. Seventy-two percent of the area currently irrigated is located in the lower half of the Basin because of more adequate ground water supplies and a larger percentage of soils which give a favorable response to irrigation (Figure 6, page 90 and Figure 7, page 91).

Total rural uses of water for agricultural activities will steadily increase during the study period. The acreage of total cropland will decrease in the Basin due to conversion to other land uses but the proportion of that land that will be irrigated will increase. The other major agricultural water uses, rural domestic and livestock, will further increase the water needs.

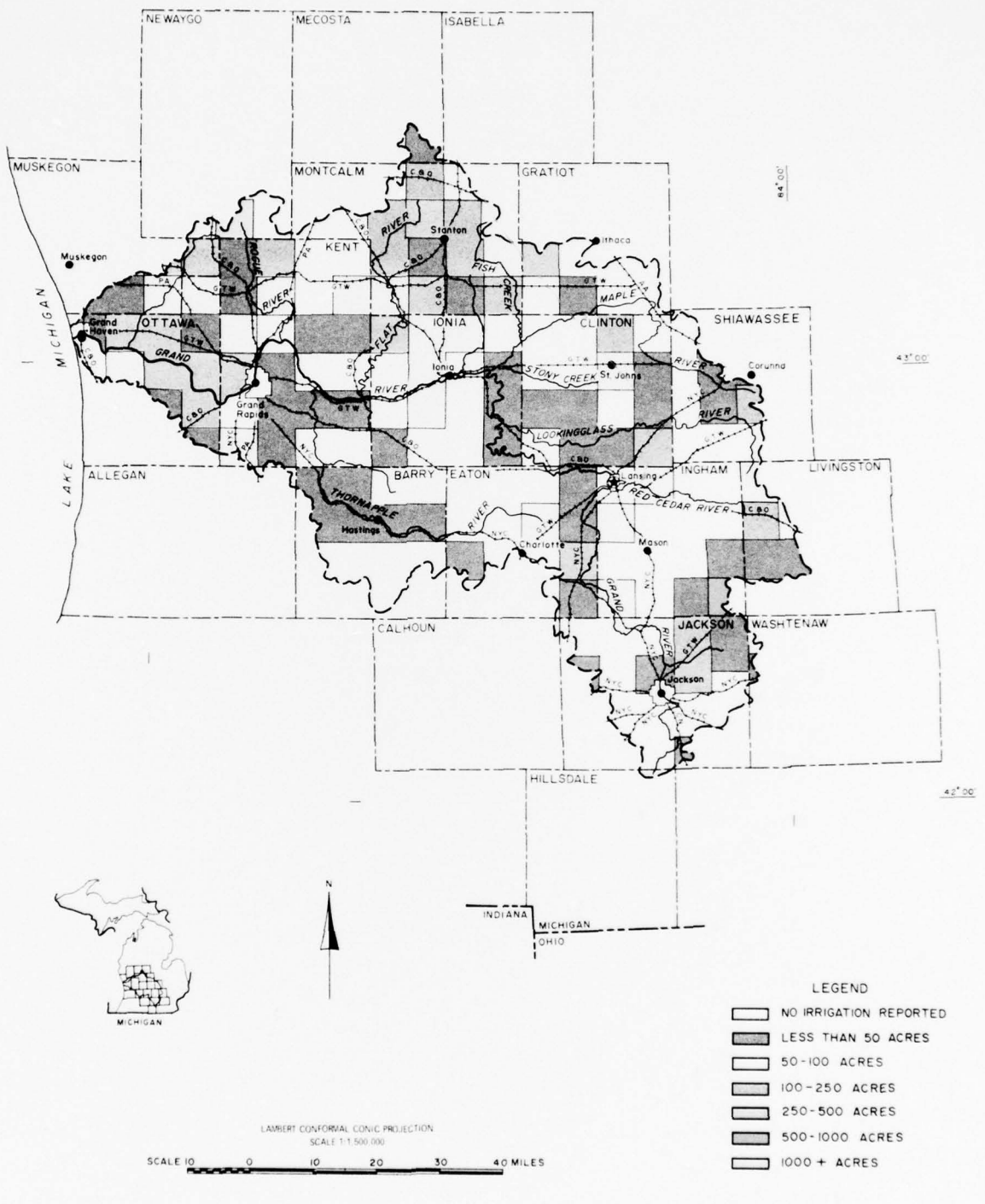
Soil Associations 2, 4, and 5 comprise the largest acreage available for irrigation, in that order (Table 32, page 92). Associations 4 and 5 would probably be more responsive to irrigation than 2, due to the higher clay content in the latter. Some of the Basin land has ideal soils for sod, fruit, and various horticultural crops, but they are too wet for evenly regulated irrigation unless they can be systematically drained prior to installing irrigation facilities.

1/ From an inventory made by Michigan Water Resources Commission

U.S. DEPARTMENT OF AGRICULTURE · ECONOMIC RESEARCH SERVICE · FOREST SERVICE · SOIL CONSERVATION SERVICE

AGRICULTURAL IRRIGATION FROM SURFACE WATER SOURCES BY TOWNSHIPS

GRAND RIVER BASIN–MICHIGAN



SOURCE:
U.S.G.S. BASE MAP OF MICHIGAN AND
DATA BY TOWNSHIP COURTESY MICHIGAN
WATER RESOURCES COMMISSION, 1964

BORDER REV. 12-22-65

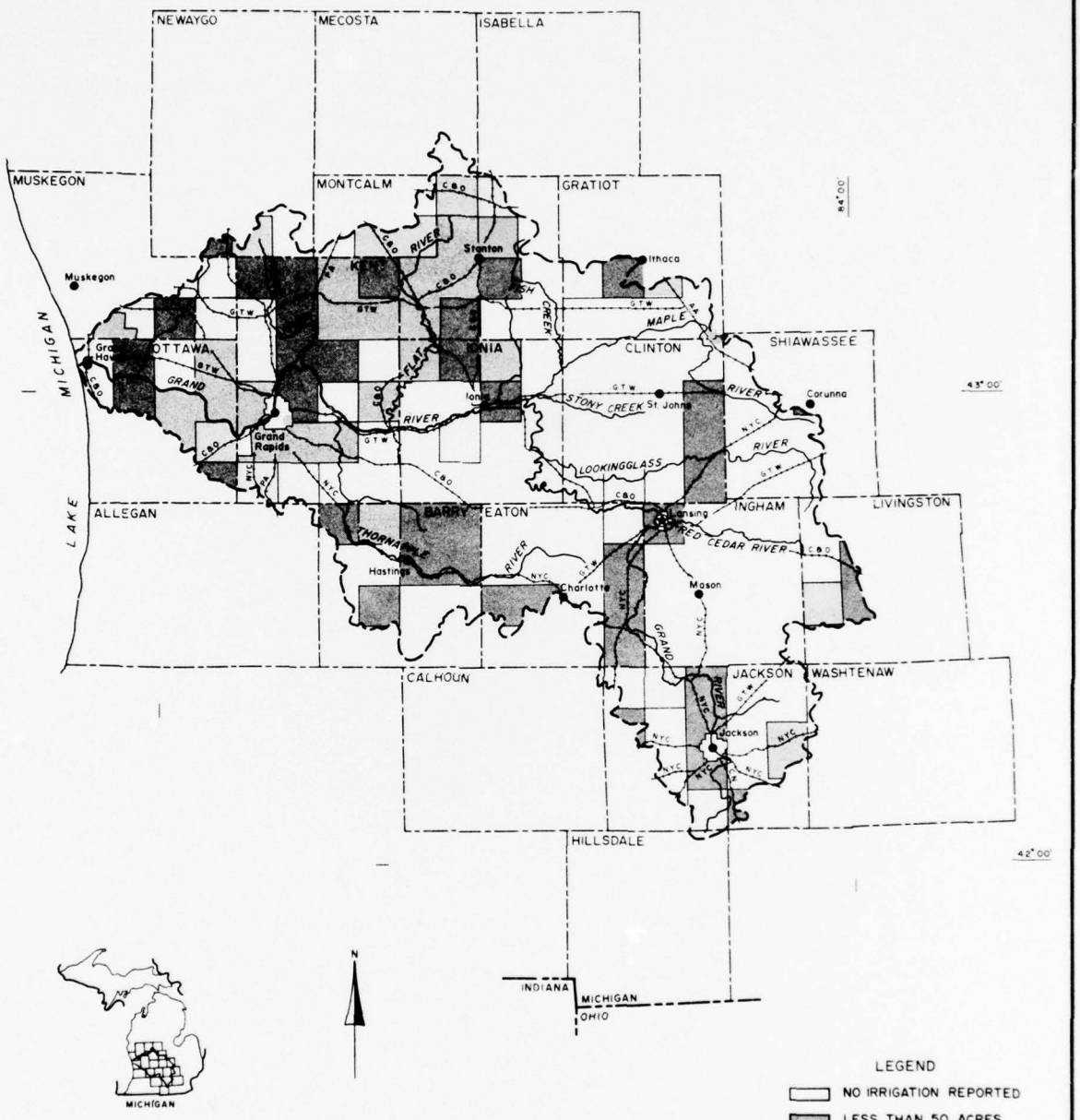
S.S.-23709

FIGURE 6 – SURFACE WATER

U.S. DEPARTMENT OF AGRICULTURE · ECONOMIC RESEARCH SERVICE · FOREST SERVICE · SOIL CONSERVATION SERVICE

AGRICULTURAL IRRIGATION FROM GROUND WATER SOURCES BY TOWNSHIPS

GRAND RIVER BASIN—MICHIGAN



SOURCE:
U.S.G.S. BASE MAP OF MICHIGAN AND
DATA BY TOWNSHIP, COURTESY MICHIGAN
WATER RESOURCES COMMISSION, 1964.

BORDER REV. 12-22-69

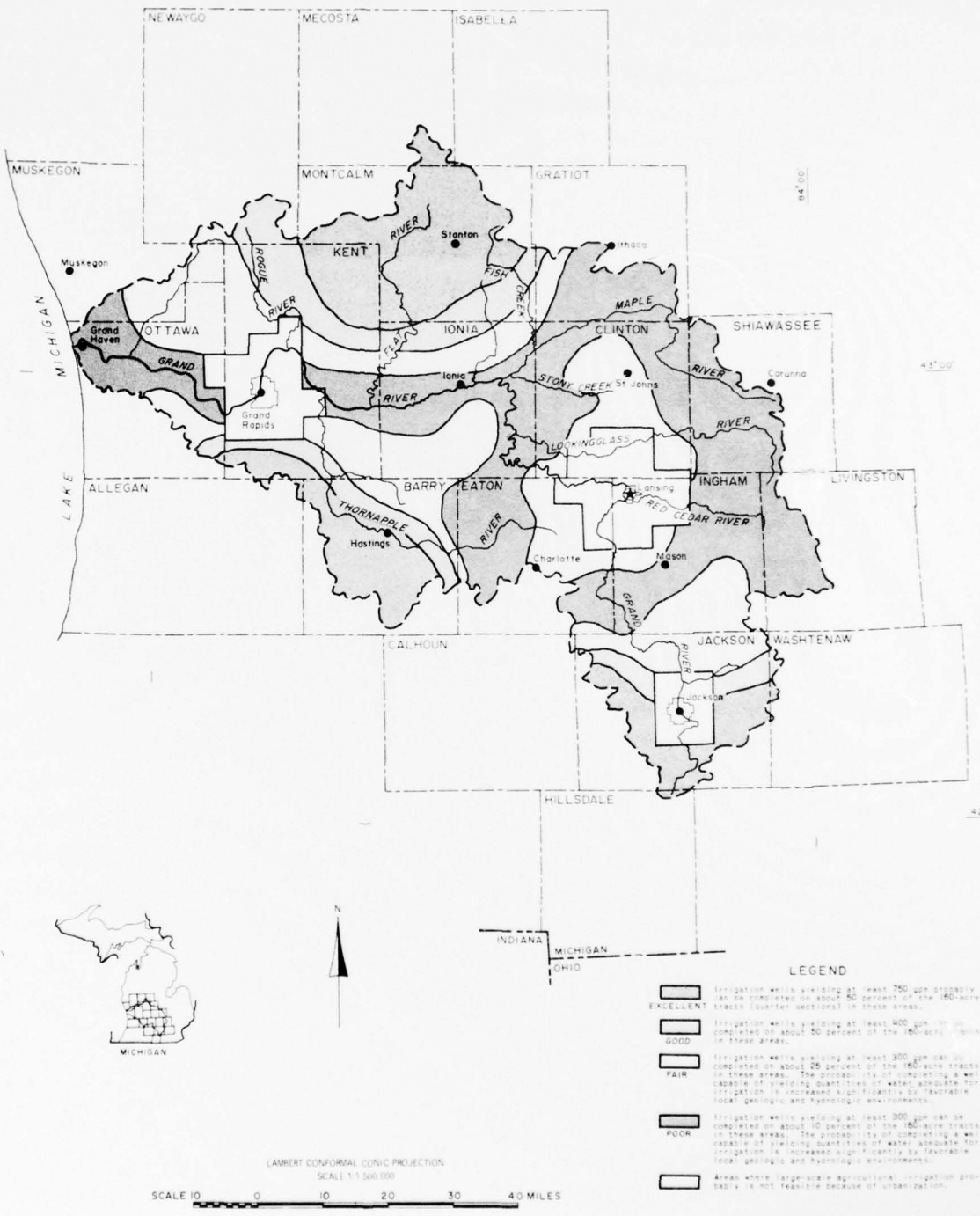
5,5-23706

FIGURE 7 - GROUND WATER

U.S. DEPARTMENT OF AGRICULTURE · ECONOMIC RESEARCH SERVICE · FOREST SERVICE · SOIL CONSERVATION SERVICE

GENERAL AVAILABILITY OF GROUND WATER FOR IRRIGATION FROM BEDROCK AND GLACIAL DRIFT AQUIFERS

GRAND RIVER BASIN – MICHIGAN



SOURCE:
U.S.G.S. BASE MAP OF MICHIGAN AND INFORMATION PREPARED BY K.E. VANLIER FOR U.S.G.S. WATER RESOURCES DIVISION IN COOPERATION WITH U.S. CORPS OF ENGINEERS.

S.S.-2372

FIGURE 8

TABLE 32 - Acreage of Cropland Available for All Crops and Row Crops Under Irrigation, 1980, 2000, and 2020[1/]

Grand River Basin, Michigan

Soil Association	All Crops			Row Crops		
	1980	2000	2020	1980	2000	2020
	(1,000 Acres)					
1	35.9	34.2	31.5	18.8	19.5	19.2
2	598.8	556.8	509.8	393.7	395.7	378.8
3	96.6	92.5	86.2	92.9	92.5	86.2
4	461.8	402.6	354.2	324.6	299.4	276.0
5	210.3	189.9	168.6	167.9	148.8	148.2
6	73.9	69.9	63.8	56.1	56.0	53.5
7	20.7	7.3	2.7	20.7	7.3	2.7
Total	1,498.0	1,353.2	1,216.8	1,074.7	1,019.2	964.6

1/ Represents the available cropland base for the production of all crops and row crops which has a physical potential for irrigation without further resource development. Minor crop and urban related acreages have been removed. From unpublished irrigation study. ERS. 1966

(2) Drainage

Drainage problems have long been of major concern throughout the study region. Agriculturally, excess water becomes a problem when it interferes with tillage, land preparation, the development of plants, and harvest operations. All of these problems contribute to reductions in crop production, increased production costs, delay in planting, and reduced quality of the products grown.

Agricultural drainage is the removal, by artificial means, of excess water from the soil to enhance agricultural production. Drainage problems may be due to excesses of surface and/or subsurface water. Surface drainage problems exist generally where the drainage network is underdeveloped and the land has a lack of relief. Surface ditches and channels are usually installed. The installation of drain tile is the most common way of accomplishing subsurface drainage. But even adequately tiled lands may not sufficiently drain the fields unless there are enough outlets and channels capable of handling excess water. Additional drainage problems exist on depressional organic soils.

The glacial till soils of the Basin are generally most productive when adequately drained, but substantial acreages still remain in need of treatment. A portion of the 635,000 acres of lands in the Basin with excessive soil moisture suffer from a lack of good drainage. Flooding accounts for the wetness problems on the remaining acreage. Since the acreage with drainage need is generally quite level, the space is assumed to be available to either row or close-grown crop production. The largest area of soils with a drainage problem falls in Soil Associations 2 and 3.

b. Nonagricultural Use The fine textured soils and relatively flat topography of much of the Basin also creates problems of drainage on the urban areas. The municipalities and industries in the region require large amounts of water now; their future requirements are expected to markedly rise.

Much damage occurs in urban areas because of inadequate drainage systems and restricted outlet conditions. Sprinkler irrigation needs will increase as the number of golf courses increases. Major

problems of water supply involve water level fluctuations, water quality, and inadequate facilities and waterways to accommodate the expanding uses of water in commerce and recreation. Control of erosion, sediment, and floods in the nonagricultural areas are other problems.

Heaviest nonagricultural water use occurs during the summer when there is low rainfall replenishment, high temperatures and evaporation rates, and low water flow rates. These problems are in marked contrast with the potential of flood in some of these areas in the springtime.

2. FLOODWATER DAMAGE

Inundation by floodwater causes damage to both agricultural and nonagricultural interests that occupy the floodplain region of the upstream areas in the Basin.

Approximately 635,000 acres of all lands (cropland, pasture land, wood land, and other lands) in the Basin have a wetness problem from either flooding and/or lack of good drainage.1/ The estimated losses on the 284,000 acres of cropland are presently $3,550,000 annually. These problem areas are identified by somewhat poorly drained, nearly level soils. Flooding poses distinct problems on 90,000 acres of floodplain land, located primarily in the upstream parts of the watersheds and their tributaries. Damage from flooding alone is estimated to be $1,215,000 annually.

Flooding damages are identified by types to better describe their actual character. One type is flooding damage to crop and pasture land. Other agricultural losses include dead and missing livestock, fence damage, and farm equipment damage. Floods reduce yields by direct damage to crops and also cause delays in spring planting and replanting. Flooding and the danger of flood damage affects the optimum land use and prevents development of bottomlands.

A second type involves damage to homes, commercial and industrial properties, parks, school sites, and other nonagricultural areas. accelerated expansion of urban-industrial and residential sites in the near future using improper land development practices will add to the dangers of flooding damage. Unsound land use techniques in the rural

1/ 1958 CNI data.

areas will both raise the water volume being passed at times of peak storm flows in the stream channels and "silt in" in the channels, thus reducing and restricting their carrying capacity. Roads, bridges, railroads, and other transportation facility structures are also vulnerable to flooding damage. The rising costs of repairing floodwater damages on residential, commercial, and industrial properties will make flood prevention even more important in the future planning of either rural or urban development sites.

Floodwaters cause soil erosion and sediment deposit damages in the upstream areas. The erosion damage consists of streambank erosion and floodplain scour. Sediment harms the land through deposition damage or swamping damage. Deposition damages occur when infertile sediment is deposited on the land. Swamping damage occurs when stream channels become clogged with sediment.

3. LAND USE AND MANAGEMENT

Use of the land both affects and is affected by the availability of the water resource. Major existing problems associated with agricultural, forestry, and various nonagricultural uses of the Basin lands include improper land uses, soil erosion losses, extensive local sedimentation difficulties, lack of using desirable conservation practices while developing the land, failure to meet changing land use needs, and insufficient development of multiple-use concepts for all Basin lands.

a. Agricultural Land In 1958, nearly 68 percent, or 1,315,500 acres, of the land expected to be in cropland use by 1980 was estimated to have one or more conservation problems.1/ In the last 10 years, the acreage needing attention including recurring needs, has been reduced to 748,000. The dominant problems are excess water, soil erosion by wind or water, and unfavorable soil conditions. Most of the land whose primary problem is soil conditions also has a secondary problem of wind or water erosion.

1/ CNI data, 1958.

Wind erosion is a serious problem on organic soils, resulting in soil loss and crop damage.

UNCONTROLLED WIND AND WATER

Unprotected waterways are subject to serious erosion.

PROBLEMS ON FOREST LAND

Livestock grazing caused this erosion on forest land.

Livestock grazing and forestry interests are not compatible.

Overstocking of forest land restricts tree growth.

Soil erosion results from overgrazing pastureland.

RURAL • URBAN PROBLEMS

Uncontrolled runoff floods valuable agricultural lands.

Erosion of unprotected residential sites produces large quantities of sediment in developing areas.

About 62 percent, or 184,000 acres, of the expected pasture-land in 1980 was estimated to have one or more conservation problems. Acreage needing attention has been reduced through treatment measures in the last 10 years to 149,000 acres. Nearly 2,000 acres have an erosion problem. Dominant problems on the water-scarce pasture areas are poor or non-existent pasture grass and poor vegetative cover. In wet areas the problems involve excessive water and deteriorating vegetative cover.

b. Forest and Woodland Throughout the Basin, various land use, management, and conservation problems were identified as existing in 1958 on 397,000 out of 536,250 acres classed as forested land. This area requiring attention is projected to be 451,000 acres by 1980. The amount of acreage treated in the last 10 years has been offset primarily by the increase in rural lands, previously cropped or pastured, that are reverting naturally to a forest-cover (where the density is equivalent to a stocking level of 10 percent or more).

Private land owners that are not interested in managing their woodlands as a renewable resource, along with the use of poor harvesting and logging practices and permitting livestock to graze through the woodlots, have caused a deterioration of tree quality and hydrologic condition. This damaging use or misuse has increased the amount of surface runoff from these areas and with it the potential for erosion and sedimentation. Approximately 15 percent of the forested land is presently in poor to fair hydrologic condition.

The growing Basin population and economy is projected to result in an increased use of forest land for wood products and other competing uses, such as recreation, wildlife, home-sites, and urban expansion. The growth rate of trees presently exceeds the rate of cut. But with the future demands upon forested land for other than wood products, a problem arises of getting more intensive management for a sustained yield of quality forest products on increasingly smaller land units and from fewer existing forested areas, yet still doing it economically.

The average forest land holding is 15-20 acres and 94 percent of the commercial forest land is privately owned. These small timber holdings, by themselves, may yield low financial returns to the owner and logger due to high operation costs and poor quality of the products harvested.

The relatively small volume and low quality of products available from individual woodlands presents economic obstacles to efficient marketing. This situation, in which many woodland owners find themselves, is partially a result of mismanagement or no management at all.

There is a projected shift in land use with less crop land required to produce food and fiber for the Basin. There were approximately 85,000 acres of idle open land and poorly stocked commercial forest land suitable for reforestation in 1958. This area is projected to increase to 139,800 acres by the year 1980. The problem will be how to successfully encourage the planting of this land to desirable commercial tree species to improve timber and watershed values before various undesirable species pioneer on the sites.

About 11 percent of the forest land is being damaged by domestic livestock. This has caused a reduction in tree quality and growth and has affected the hydrologic condition. Young trees and other ground cover are destroyed or retarded by browsing and trampling. The infiltration rate is also reduced due to compaction of the ground surface.

Many of the forested areas are affected by insects and diseases. The level of infestation varies but is most noticeable in overmature trees. Insects and diseases cause not only mortality but hinder the growth of quality trees.

The number of people living in metropolitan and suburban areas is steadily increasing, forcing expansion into the surrounding area which, in many cases, had been rural in nature. With increasing demands for land development in cities and suburbs,forested land is gradually being eliminated from these areas; the condition of the remaining forested areas is deteriorating from overuse. The loss of trees and shrubs, along with the excessive use of the remaining woodlands, has

led to the destruction of environmental values in many areas. Although beautification in a formal manner is understood and more readily developed, the management of trees and associated plants for sylvan aesthetics, nature studies, microclimate control, hydrologic values, and related benefits is not receiving enough consideration.

Most rural wooded areas in the Basin are held in a condition of nondevelopment. Very few owners visualize their woods holdings as a calculated economic investment for sustained yields of forest products. This is, essentially, the result of low economic priority in the minds of the owners who view forest economic returns in the present and forseeable future as being low. Many owners do not understand the forestry opportunities and services that are available. Some lack the required capital or time. Some would do the work if they could hire it done. Because of these ideas about low-potential, immediate returns, and the assumed difficulty of woodland improvement, many owners are not interested enough to take time to properly develop their forest resources. Of those who do attempt development of idle lands, many proceed with little or no planning. Often they plant trees without adequate ground preparation or consideration of species, and then do not take care of the plantation after it is established.

In short, what is generally important in terms of the social good of the resource is not always considered important by the individual. Consequently, only a fraction of the woods are being properly managed.

The present fire protection programs have aided in the natural revegetation of previously exploited and burned over forest lands and helped in the devebpment of tree plantations. The risk of fires is still great and becoming more so each year as the woods become more available to public use and as plantations are being established on idle lands that are also growing grass or other flashy fuels. The leading cause of fire in private forested areas in the Basin is debris burning where the use of fire for land clearing, pest control, and trash burning gets out of control.

c. Nonagricultural Land Use An increasing amount of agricultural and forest land is being converted to nonagricultural uses in the Basin. Problems associated with the misuse of the soil and water resources are prevalent on lands where uses now involve recreation and urban-industrial activities.

(1) Recreation

The Basin shares in the National trend toward the growth of outdoor recreation. Demands for recreational facilities will increase more rapidly than the increase in population.

These increased demands for outdoor recreation on the present facilities pose many problems. Many recreation areas are deteriorating from overuse. This is generally the result of poor design, unsuitable location, and inadequate facilities. But in many instances, overuse is more realistically misuse.

Improper use of outdoor recreation activities and facilities increases the sediment accumulations in the waterways in some areas. Concentrated overuse along trails and near campgrounds results in soil trampling and displacement. Use of certain cross-country vehicles, expecially "jeeps" and "trail scooters", is locally damaging to roads and trails, and adds to the sediment problems in the streams, lakes, and rivers. Misuse of recreation areas upsets the ecological balance, may cause a disappearance of some plant and wildlife species, and degrades aesthetic values.

The important role of forested lands in the development of outdoor recreation facilities will continue to become increasingly critical as wooded areas for this purpose become more difficult to find. Forest-water complexes provide attractive, scenic settings that enhance recreation potential of the lands. Such potential is further enhanced or diminished by the quality of the water and its affected environment. Heavy cuttings along streams and lake shores may destroy or drastically reduce this potential. Poor quality water and inadequate development are major deterrents to meeting projected recreation demands.

The demand for the use of land for the recreation purposes of hunting and fishing is expected to greatly increase during the study period. Hunting pressure is projected to rise by nearly 90 percent; fishing pressure will more than double in the Basin by the year 2020 (Table 33, page 101).

Historically, much of the hunting and fishing recreational demand has been met without charge on available private lands. During the study period, however, the free use of private lands by the public is expected to become more restrictive. Hunting and fishing clubs will be buying or leasing lands for purposes of providing sport for the exclusive use of their members. More and more private landowners will either prohibit free public use or charge "user" fees. Citizens accustomed to free use of lands for their sport will turn to public areas in increasing numbers. The difficulty of dispersing hunting and fishing pressure to fully utilize public areas will create problems in providing fully managed fish and game habitat with adequate public access.

The increasingly more lucrative business of selling recreation opportunities to the public will induce greater numbers of private landowners to change their land and water resource uses. Even now dozens of new private outdoor recreational businesses have been developed. But the expanding demand for these kinds of recreation has created shortages of trained personnel to manage these water and related land resource uses.

Water-oriented outdoor recreation is an important part of the total picture of recreation activities desired by the public. Boating, swimming, sunbathing, picnicking, sightseeing, and other recreation activities are popular where not restricted and where appropriate facilities are available. Many areas in the Basin do not presently satisfy the demands for water-based recreational activities despite the nearly unlimited recreation potential of the State. Public access to beach, boat-launching, and harbor facilities is limited. Much of the shoreline along the interior lakes is held in private ownership and is not available for public access. Many parts of the shorelines have become

TABLE 33 - Present and Future Demands for Hunting and Fishing

Grand River Basin, Michigan

Activity	1960	1980	2000	2020
		(1,000 Man-Days)		
Hunting	1,459.2	1,591.3	2,097.2	2,769.2
Fishing	1,695.8	2,165.6	2,869.2	3,013.5

Source: A compendium of projection data related to future hunting and fishing demand - Grand River Basin, 1960-2020, U. S. Fish and Wildlife Service, 11/29/65.

aesthetically undesirable for recreation uses. Public recreation parks and development are inadequate in number and facilities. There is a general shortage of recreational opportunities near the metropolitan areas where the demand is greatest.

Many areas with suitable relief, water, and forest cover which are adaptable to recreational development are being absorbed by land use changes and are becoming unavailable for recreation pursuits. Disorderly land development in urban expansion, industrial development, and summer home complexes is using many of the better areas, those often equally suited for agricultural, forestry, and recreation uses. These are often areas of abundant or potentially abundant wildlife resources. The challenge of satisfying recreational demands will become increasingly more difficult if these areas continue to succumb to poorly planned and unrestricted urban area development.

(2) Urban-Industrial Land Transition

The transition of rural areas into suburban development intensifies existing problems and creates new ones. Such growth is often poorly planned and rapid, proceeding in "leaps and bounds". It may bypass economically and socially less-desirable areas through which basic services must be extended to reach the new suburbs.

Rapid, new development brings a greater chance of storm water damages, encroachment upon flood plains, and accelerated decay and blight of the urban environment. Soils that have been disturbed and remain unprotected on or adjacent to construction areas suffer erosion in a very short time period. This erosion contributes to the pollution through sedimentation.

Surface mining will effect land and water resources. Scattered areas involving sand and gravel pit operations have problems involving erosion and pollution. The loose soil is washed and/or blown off the open pit areas to be deposited in waterways and on highways and fields. Erosion from access and haul roads associated with mining operations adds to the sediment problem.

4. EROSION AND SEDIMENT DAMAGE

Wind and water erosion was found to be the dominant conservation problem on nearly ten percent of the Basin land area. The CNI in 1958 identified 339,000 acres of cropland, 2,100 acres of pasture, and 6,550 acres of forest land in this category. Runoff water causes sheet, rill, gully, and streambank erosion. Sheet erosion, as well as blow-out or dune erosion, is also caused by wind action. Excessive erosion reduces the ability of the land to produce economically successful crops and ultimately results in the destruction of the land resource. It is also the source of the sediment pollutant in the waterway and standing-water resources.

Sheet and rill erosion describe the removal of soil or other material from the land surface by the action of wind and/or rainfall, and by runoff water. Sheet erosion is the removal of a fairly uniform layer of soil. Rill erosion is the formation of fairly shallow channels that can be smoothed out by normal cultivation. Gully erosion is the removal of soil (or other materials) from the land surface by flowing water with the formation of channels that cannot be smoothed out by normal cultivation. Streambank erosion is the removal of soil from the sides of rivers and streams, occurring principally during flood flows.

Sheet and gully erosion are most damaging on the open and untreated areas. Improper management on agricultural and forested land increases the erosion potential. On-site economic losses from gully erosion accrue from the value of the lost soil and its production potential in the voided areas and from depreciated values of the adjacent lands. Off-site economic losses occur from sedimentation of surface waters, crops, fences, and building sites. Poor logging practices, along with improper construction and location of logging roads or skid trails, contribute to the erosion problems.

Moderate to severe erosion damage occurs on such nonagricultural land as highways banks, unsurfaced secondary roads, bridge embankments and approaches, road culverts, and business, residential, and other construction sites. Urban and suburban development without proper consideration for the soil conditions often create major erosion

problems. These eroding areas are difficult to control and require large, often expensive corrective measures.

Streambank erosion is a problem causing heavy soil loss and poor water quality. The amount and severity of the erosion differs widely within the tributaries of the region because of variations in land use, climate, topography, and geologic origin of the soil.

Wind erosion can be a serious problem on occasion in localized areas of the Basin, but overall it is not a major problem.

The rate of erosion, sheet and rill, as well as gully, is dependent on many factors -- rainfall, slope steepness, slope length, vegetative cover, soil type, and management.

The weighted mean rate of sheet erosion now occuring on Basin cropland has been determined to be 3.11 tons of soil loss per acre per year (t/a/y) Table 34, page 105).[1/] On the 1,940,000 acres of cropland, (CNI, 1958), this amounds to over 6 million tons of topsoil being moved to other sites. Sometimes these new sites are other cropland, but more often they are alluvial bottomlands and flood plains. Nearly half of the tonnage of displaced soils winds up in waterways as sediment.

Although the weighted mean erosion rate of 3.11 t/a/y/ is not particularly alarming, an examination of the erosion rates within the various soil groups does cause concern. Soil Association 2, typically the Miami-Conover soils, occupies more area in the Basin than the other soil groups -- over one-third. This soil group has a markedly higher predicted erosion rate - 4.26 t/a/y - than the weighted mean. In examing the range of sample erosion rates for this group, they show a high of 12.13 t/a/y. About half of the 6 million tons of cropland estimated to be displaced yearly occurs on just over one-third of the Basin cropland area -- on Soil Association 2 lands.

Sheet erosion losses on permanent pasture lands are predicted to be much less than on cropland. The weighted mean rate is 0.4 (t/a/y). Although the range of sample erosion rates of Soil Association 2 shows a high of 1.07 (t/a/y), the weighted mean is 0.38, a little lower than the weighted Basin-wide mean.

1/ The rate of water-transported soil erosion is predicted through the Universal Soil Loss Equation.

TABLE 34 - Sheet Erosion Rates on Crop and Pasture Land

Grand River Basin, Michigan

Cropland[1] (Row Crops, Sm. Grain, Rotation Hay-Pas.						Permanent Pasture[1]				
Soil Assoc.	Per-Cent	Acreage (1,000)	Erosion Rates - Tons/Acre/Year Low	High	Mean	Percent	Acreage 1,000	Erosion Rates - Tons/Acre/Year Low	High	Mean
1	2.6	49.7	0.81	3.43	2.57	1.6	4.7	0.20	0.85	0.52
2	37.2	721.9	0.32	12.13	4.26	33.3	98.9	0.11	1.07	0.38
3	8.8	170.5	0.29	7.16	3.76	6.3	18.6	0.11	0.35	0.23
4	29.4	569.4	0.13	4.70	2.16	21.7	64.3	0.13	0.98	0.32
5	13.9	269.8	0.27	5.34	3.08	19.8	58.8	0.09	0.30	0.21
6	4.4	85.9	0.19	9.80	2.06	3.9	11.6	0.07	0.61	0.70
Other Groups	3.7	72.8				13.6	40.0			
Total	100.0	1,940.0			3.11[2]	100.0	269.9			0.41[2]

1/ Acreages were taken from the 1958 CNI; erosion values were determined from the revised CNI (1966 - unpublished).

2/ This is the weighted average based upon area distribution of the soil associations.

Erosion in agricultural areas is generally more severe in early spring than at any other time of the year. Freshly cultivated fields are devoid of vegetation at that time, and even the natural regrowth on fall-plowed fields is insufficient to deter large scale erosion during the major water runoffs in the spring. Long steep slopes are many, many times more potentially erosive than short flat slopes. Unvegetated open ground is vulnerable to the full force of impact of the raindrops and to the total energy of the scouring action of the surface runoff. Under the same eroding influences, different soils have varying susceptibilities to erosion. Soils fall into the following order of erodibility from least to most erosive: surface soil with a high percentage of very coarse material, coarse textured soil, fine textured soil, and medium textured soil.

Erosive losses of soils on forested lands, just as in pasture lands, are quite low and cause few problems. Erosion losses have been predicted to be 0.1 tons of soil loss per acre per year. This amounts to over 50,000 tons of soil displaced from its original forest and woodland sites yearly. Soil erosion rates on nonagricultural lands have not been sufficiently studied or measured in the Basin to permit soil loss predictions. One study in urban areas in Southeastern Michigan produced data suggesting a rate of 3 tons of soil loss per acre per year as the average soil loss for the average suburban-urban area.[1/] But half that total amount in tons occurred on those parts of the area that were open and bare during construction on the sites; only two percent of the area was open at any one time. During construction the accelerated erosion rate on the bared sites averaged 69 t/a/y, but similar lands after adequate vegetation restoration and land treatment had rates of only 0.25 t/a/y.

Sedimentation from erosion of land has been recognized as one of man's major problems since ancient time. Another Michigan study made north of the Basin (in Clare and Gladwin Counties) produced data which

1/ Unpublished, Soil Conservation Service, USDA, 1968.

showed a relationship between land use and sediment discharge rates. No such study has been made in the Basin. Sediment discharge rates increased as the proportions of cultivated and poorly managed pasture land increased. Sediment discharge rates decreased as the proportions of forest, "wild", 1/ and well-managed pasture land increased. Although the results may not be precisely comparable to Basin conditions, the trends and generalities suggested are probably similar.

Deposition of sediment on fields, in drainage ditches, and in streams, rivers and ponds causes severe damage in the Basin. Sediment deposition damage to land occurs mainly from flooding or heavy spring runoff. Sediment carried by floodwaters results in infertile overwash, swamping, and increased inundation. It covers and destroys field crops, reduces crop yields, and delays field management operations.

Deposition in forested areas destroys wildlife habitat and recreation opportunities, and hampers the harvest of forest products.

Field and streambank erosion contribute to the sediment load in waterways which damages and fills in channels, ponds, and reservoirs. It impairs drainage channel openings, thereby raising the field water levels. Periodic removal of the sediment from the drainage ditches and waterways is costly and time-consuming. Such sedimentation reduces the value of rivers and ponds for fish habitat, water storage, and other uses.

5. POLLUTION

Water pollution from waste materials, erosion, chemical sprays, and other sources contribute to poor water quality which is one of the major problems of the Grand River Basin. This pollution increases the treatment cost of water for domestic and industrial uses and is harmful for recreation, fish, and wildlife use.

Water pollutants, originating in part on agricultural land can be grouped into five categories: sediment, plant nutrients, waste products with high oxygen demands, infectious agents (fecal coliform and streptocci), and exotic chemicals (pesticides, herbicides, etc.).

1/ Includes brushlands, non-forested bogs and swamps, abandoned land, and other idle land, usually well vegetated by grass with little erosion potential.

Sediment pollution creates problems for recreation, fish and wildlife, and municipal and industrial water supply development. It restricts full use for these purposes and is quite expensive to properly correct. It degrades the appearance and aesthetic value of the water resource.

Plant nutrients, that find their way into streams, help to stimulate excessive aquatic plant growth which may also taint the water with foul tastes or odors. Some nutrients, nitrogen and phosphorus in particular, become unavailable to plants through leaching and or loss due to erosion. While increased usage of chemical fertilizers is projected, there are several management practices that can be employed to help minimize this loss. These improved practices are expected to be carried out in the future and relate to appropriate timing of application, deep placement of fertilizers, and cultural practices designed to minimize surface runoff.

The nutrient levels carried by the water is projected to increase during the study period as the use of chemical fertilizers grows.

Plant residue and animal manure wastes, carried in the surface runoff from farms to the rivers, exert a high oxygen demand on the water. Livestock wastes are especially strong pollutants since they do not receive the sanitary treatments accorded human wastes. In terms of bulk waste production, one cow is considered equal to 16 humans. Agricultural waste pollution in the water markedly disrupts the ecological balance of the aquatic communities, principally affecting fish populations.

An increased population and greater industrialization pose severe problems of disposal of human sewage effluents and industrial wastes from large metropolitan complexes. Serious water-quality problems exist downstream from the major cities in the Basin.

Exotic organic chemicals, such as insecticides, herbicides, and pesticides, have beneficial uses in both agricultural and nonagricultural situations. Problems are arising in the Basin as the level of chemical residues builds up, both in the water and on the land. Expanded use of these chemicals will compound the problems during the study period.

6. IMPAIRMENT OF NATURAL BEAUTY

Many of the problems concerning resource availability and use, flooding, pollution and erosion also cause negative effects upon the beauty and scenic attractiveness of the Basin. The quality of the environment often determines the extent of appreciation of the water and land related resources.

Marked, seasonal water level fluctuations create conditions detrimental to sustaining the natural beauty of the Basin's water resources. Lowered water levels and flow rates often stimulate excessive aquatic plant growth over much of the surface area of shallow lakes and ponds. Aquatic plant growth is generally more appreciated when limited to a part of the shoreline edge. Rapidly lowered water levels leave barren pond banks exposed, creating temporary "eyesores" as well as potential erosion sites.

Misuse of both the land and water resources creates availability, erosion, and pollution problems. Beauty spots in recreation areas can be abused through misuse to the point of deterioration. Woodlands can lose their beauty and the aesthetic appreciation which people have for them if poor management practices are permitted. Trash and refuse dumping, and other forms of pollution abuse the appearance of the Basin's waterways and cut down on their availability for other uses.

Uncontrolled erosion contributes to excessive sedimentation and the murky brown coloration of the waters in some areas of the Basin. Sediment build-up hampers regular water movement along stream and river channels, disturbing the aquatic plant and animal communities. Sediment fills in and minimizes use of the reservoirs and impoundments for recreation pleasures, as well as negating the flood preventative values of these structures. During floods the sediment and other water polluting materials are left on the land to smother plant life and cover the existing top soil. The thick, covering layer often carries a strong odor besides presenting a nauseous appearance.

The natural appearance and acceptable taste of the Basin's water

resources are being altered by pollution with agricultural and industrial chemicals, organic wastes, and inorganic salts and minerals. These and other polutants often give the waters strong, repelling odors. Sediment and mankind's manufactured materials blight the water's appearance and restrict other uses.

The impairment of natural beauty must be recognized as a problem for which improvements should be considered in resource development in the Basin. As the number of people living in metropolitan and suburban areas has increased, so has the need for protection and establishment of natural areas. This has become a severe problem. Its solution has been complicated by increasing competition for land. Conditions for plant growth have steadily deteriorated because of air pollution, drought, erosion, heat, mechanical hazards, poor soil, and other adverse influences resulting from construction and concentration of use. The loss of trees and shrubs has, in turn, led to the destruction of environmental values. The amelioration effect on air temperature and humidity, dampening of harsh sounds of the city, beneficial effects on air pollution, reduction of erosion and sedimentation, protective influence on water supply and the beauty of natural surroundings -- these are all affected by the presence or lack of trees and plants in and around urban communities. Many State, community and private land areas are deteriorating rapidly because of over use, destructive land use practices, and lack of knowledge of the principles of resource management to protect and improve the environment.

SECTION V

PRESENT AND FUTURE TOTAL NEEDS FOR WATER AND RELATED LAND RESOURCE DEVELOPMENT

1. WATER NEEDS

The urgency in solving the complex of problems involving water use will become increasingly more critical as the human population and their water needs grow. The agricultural uses of water are expected to increase during the study period, with emphasis being placed on row crop irrigation and land drainage. The water needs for nonagricultural uses will become even more important. Water needs for recreation, domestic household, and industrial uses will increase significantly, particularly as more and more land is converted to these uses.

a. Agricultural Uses The major agricultural activities that use water directly, i.e., livestock production, rural domestic household activities, crop irrigation, and cropland drainage, involve the handling of both ground and surface water supplies. Ground water sources are more efficient and dependable, but are becoming more expensive to use as water tables recede. Better utilization of both types of supplies is needed in order to satisfy the expected increases in crop irrigation, rural domestic and livestock uses. Improved water retention methods need to be found to combat seasonal shortages at critical times of the growing cycles.

(1) Irrigation

The amount of agricultural land which will be irrigated is expected to increase during the study period. The amount of water required to irrigate these added acres will also increase.

In 1964, 11,370 acre-feet of water (approximately 3,705 million gallons) were used to irrigate 21,167 acres.[1/] Most of the irrigated land was planted to truck crops, fruit, and potatoes, but it also included some nonagricultural irrigation of golf courses, parks, and ceme-

1/ From an inventory made by Michigan Water Resources Commission.

TABLE 35 - Acreage of Certain Irrigated Specialty Crops by Soil Association with Acre Inches of Water Required, for 1960 and Projections to 2020. 1/

Grand River Basin, Michigan

Soil Association	1960			1980			2000			2020		
	Vegetables	Fruit	Small Fruit	Vegetables	Fruit	Small Fruit	Vegetables	Fruit	Small Fruit	Vegetables	Fruit	Small Fruit
4				7,496	14,025	2,277	8,140	17,306	3,096	9,184	20,810	4,287
5				4,278	13,436	2,320	4,568	16,641	2,977	5,105	19,296	3,974
7				17,804	--	--	20,164	--	--	23,414	--	--
Total Acres Grown	16,381	20,432	1,568	29,578	27,461	4,597	32,872	33,947	6,073	37,703	40,106	8,261
Percent Irrigated				43.52	7.24	42.27	51.39	11.21	45.56	59.58	15.18	48.86
4				3,262	1,015	962	4,183	1,940	1,411	5,472	3,159	2,095
5				1,862	937	981	2,347	1,865	1,355	3,042	2,929	1,942
7				7,748	--	--	10,362	--	--	13,950	--	--
Total Acres Irrigated				12,872	1,988	1,943	16,892	3,805	2,767	22,464	6,088	4,037
Ave. Application in Acre-inches				7.78	3.81	8.60	7.71	3.81	8.26	7.64	3.81	7.98
4				25,378	3,867	8,273	32,251	7,391	11,655	41,806	12,036	16,718
5				14,486	3,707	8,437	18,095	7,106	11,201	23,241	11,159	15,497
7				60,279	--	--	79,891	--	--	106,578	--	--
Total Acre-inches Applied				100,143	7,574	16,710	130,237	14,497	22,856	171,625	23,195	32,215

1/ From unpublished irrigation study. ERS, 1966.

teries.

The pattern of irrigation was estimated through use of an economic budgeting procedure which estimated the extent of irrigation to be practiced by Basin farmers to meet their share of the market needs. The total projected acreage of fruits and vegetables under irrigation in 1980 is nearly 17,000 acres (Table 35, page 112). The irrigated acreage of these crops is projected to be 23,000 in the year 2000 and 32,000 in 2020. Vegetable crops account for the major acreage to be irrigated. The gross need of water for all specialty crop irrigation will increase to 10,400 acre-feet per year in 1980 and to 19,000 by 2020.

Another result of the economic budgeting model indicated that the only general field crop with an economic potential for irrigation in all three projection years is potatoes. This analysis reflects only what is nost economically efficient for resource owners under an either/or set of conditions. It does not reflect the known small amount of general field crop irrigation that takes place for such other reasons as, the inability to expand a farm unit, availability of a inexpensive water source, or the incidental use of an available system that is normally used for a high value crop. Soil group 4 shows the greatest potential for potatoes. The total projected acreage of irrigated potatoes needed will be 4,100 in 1980, nearly 4,600 in 2000, and 6,200 in 2020. The gross water demands for the expected irrigated acreages will be approximately 2300, 2600, and 3400 acre-feet in 1980, 2000, and 2020 respectively.

Projections show a potential for 28,050; 36,682 and 48,044 acres under irrigation for years 1980, 2000 and 2020, respectively, which would require 25,570; 31,209 and 38,834 acre-feet of water on an average basis.

(2) Drainage

Approximately 635,000 acres of land are affected by excess soil moisture. There is an economic potential for drainage that will reduce production costs on 178,000 acres of cropland by 1980. There will be an economic potential for drainage of cropland on 134,000 acres in 2000, and 156,000 acres in 2020 (Table 36, page 114)

TABLE 36 - Acreage of Cropland Requiring Drainage and having an Economic Potential to Drain, 1980, 2000, and 2020

Soil Association	1980	2000	2020
	(1,000 Acres)		
1	25.6	4.0	7.3
2	14.4	35.5	62.0
3	16.4	61.4	55.2
4	74.6	5.9	7.3
5	31.0	--	19.2
6	11.4	--	1.6
7	4.3	26.9	3.7
Total	177.7	133.7	156.6

Of the total amount needed by 1980, 23,965 acres of organic soil[1/] and 47,430 acres of mineral soil can be improved by adequate outlets within the watersheds inventoried in this study designated as having potential for early development (the next 10 to 15 years). The additional acreage of land can be obtained through the use of on-farm and small group drainage facilities.

(3) Rural Household and Livestock

Total water demands or requirements for rural domestic and livestock use in the project years are made up of three basic components: (1) water needs for all livestock consistent with the sales of livestock and livestock products, (2) water demands by the farm family and hired farm workers and their families, and (3) water to be used for the preparation of chemicals and pesticides for general farm use.

Water requirements for these uses represent the summation of totals for each class of livestock or domestic need under various assumed uses and use rates for the three projection years. It is assumed that water needs for livestock and rural domestic farm uses will be

1/ Much of the organic soil will undoubtedly be in the production of vegetables and other high-valued crops, such as sod for landscaping.

TABLE 37 - Estimated 1960-2020 General Farm, Livestock and Rural-Farm Domestic Water Requirements 1/

Grand River Basin, Michigan

Item	Annual Use			
	1960	1980	2000	2020
	(Million Gallons)			
Cows 2/ Milk	1,104.2	1,066.2	1,360.1	1,727.6
Dry Cows	93.5	89.7	101.3	117.6
Young Stock	335.9	335.9	379.3	440.2
Dairy Cleaning	26.2	84.0	189.7	220.1
Dairy Sanitizing	105.0	125.9	189.7	220.1
Liquid Manure Handling	--	4.2	23.7	55.0
Sows	23.8	33.9	55.7	69.2
Pigs 2/	76.3	114.2	187.7	241.0
Wallow	21.2	51.9	72.7	48.2
Clean-Sanitizing	--	62.3	174.4	231.4
Fogging-Cooling	--	26.0	72.7	192.8
Laying Flock 4 gal/ 100, & Young 1 gal/ 100 2/	19.7	16.4	20.8	8.3
Egg Washing	3.9	3.3	4.2	1.7
Clean-Sanitizing	.4	.5	.9	.5
Spraying-Cooling	--	3.3	8.3	3.3
Beef Cows and Replacements	75.3	112.2	219.3	348.5
Cattle & Calves 2/	351.6	408.1	657.8	968.2
Clean-Sanitizing	1.1	5.6	12.0	15.9
Turkeys 2/	35.2	49.3	71.9	100.0
Clean-Sanitizing	.5	1.3	3.3	6.8
Spraying-Cooling	--	4.5	13.1	18.3
Sheep & Lambs 2/	23.1	18.5	20.7	26.5
Ewe Flock	41.8	33.8	43.0	54.3
Clean-Sanitizing	.2	.9	1.8	2.2
Family Water Use	2,833.3	2,259.3	2,199.1	2,168.1
Car & Truck Wash	55.6	122.2	120.6	99.0
Lawn & Garden	148.2	244.5	402.0	495.0
Swimming Pool	--	18.4	101.2	202.5
Hired Workers & Family	620.5	728.2	759.2	722.7
Mortality				
Sheep (5-15%)	3.0	1.7	1.5	1.4
Beef (3-5%)	1.9	2.2	3.2	5.1
Dairy (3-5%)	23.3	17.9	15.2	17.6
Pigs (5-15%)	5.7	5.9	6.8	6.0
Vegetables	7.4	10.4	8.2	9.4
Fruit	85.8	82.4	67.9	80.2
Small Fruit	3.1	6.9	6.1	8.3
Potatoes	6.1	2.7	2.8	4.3
TOTAL	6,132.8	6,154.6	6,894.6	8,937.3

1/ Adapted from Water Systems Analysis to Meet Changing Conditions, Agricultural Engineering Department, Michigan State Univesity, Information Series 152, File No. 18.35.

2/ Product Marketed.

generated in areas of adequate ground water supplies. Farm operators would not knowingly set up an enterprise combination requiring large amounts of water in an area with inadequate natural supplies.

Under the assumptions used in this study and reflected in the data on Table 37, page 115, the 1960 need for water was 6.1 billion gallons. Family water use in the home accounted for 46 percent of the total and the consumption by dairy cattle in the production of milk also required a large quantity of water.

Rural home and livestock total water demands are expected to increase to 6,2 billion gallons in 1980, then 6.9 in 2000, and nearly 9.0 in 2020, the latter being some 45 percent above the 1960 estimated use level. Although family water use rates rise continually over the study period, the reduction in numbers of people is sufficient to cause a downward trend in both the absolute water need and the proportion this item comprises of the total. One-fourth of all water requirements in 2020 are for family use.

b. Forest-based Industrial Uses At the present time, sawmills require very little industrial water. In 1962, there were approximately 46 commercial sawmills. Their combined annual output was estimated to be approximately 30 million board feet of lumber. The total combined present water use of these mills is not over 600,000 gallons per year. The future water demand for these mills will be a very small portion of the total industrial demands.

Presently, there are no primary manufacturing pulp mills in the Basin and only one secondary manufacturing paper mill, located at Rockford in Kent County. Its present use is one million gallons per 24 hours of operation, which is projected to double by 2020.

c. Nonagricultural Uses Water-oriented outdoor recreation is an important part of the total recreation needs of the Basin. Many areas in the Basin are severely limited with respect to the supply of outdoor recreation facilities.

The Bureau of Outdoor Recreation provided recreational demand projections for four of their designated subareas within the Basin. These subareas and their included counties are as follows:

Subarea	Counties
Jackson	Jackson
Lansing	Clinton, Eaton & Ingham
West Central	Barry, Ionia, & Montcalm
Grand Rapids	Kent & Ottawa

The Lansing Subarea is the source of greatest demand followed by the Grand Rapids, West Central, and Jackson subareas in descending order.

The total projected demands for the years 1980, 2000, and 2020 were approximately 14.4, 24.3, and 37.7 million annual occasions respectively.[1/] Five major outdoor recreational activities were considered in these projections: three water-dependent activities--swimming, boating, and waterskiing, along with two water-enhanced activities--camping and picnicking. These five activities are commonly carried on at sites of or associated with federal water resource development projects. Financing the development or enhancement of these activities, in terms of land acquisition, facility construction, and operation and maintenance of such facilities, constitutes a considerable share of the costs allocated for recreation area development at federal projects.

Water-enhanced recreation in a forested setting, especially where there is an adjoining development for land-oriented recreational activities, is desirable and is considered necessary. Camping and picnicking in wooded areas are vastly improved by adequate supplies of good quality water, both for drinking and camp sites uses and for aesthetic beauty and scenic enhancement. Waterfoul and sport fisheries also depend upon quality water as a biological need. Good forest management practices must be emphasized to insure high-quality runoff for recreation and other uses, while meeting the increasing need for wood products.

Industrial needs for water will increase as the economy of the Basin expands and prospers. Although the extent of water degradation by industrial uses is small when viewed on a basin-wide basis, critical problems are created in local situations. Effective regulations on water

1/ Annual occasions are the total projected number of occasions that persons will enjoy during the entire year.

use are needed to help guide industries in the proper use of this resource.

Meeting the water needs and demands of an expanding, urban population has become one of the major challenges in the Basin. In some portions of the Basin, water is being taken from the ground water supply faster than it is being replenished. Greater use must, therefore, be made of the surface and impounded waters, along with developing better water reuse methods.

2. FLOODWATER PREVENTION AND WATERSHED PROTECTION

Flood prevention and/or improved drainage is needed on the 635,000 acres in the Basin now vulnerable to floodwater damages or having wetness problems. Flood preventative measures are needed on 90,000 acres of distinct floodplain lands.

Floodwater retarding structures and/or multiple-purpose channels (flood-prevention and drainage) are required to alleviate conditions of frequent flooding and impaired drainage. Non-structural conservation measures for watershed protection are needed on 1.2 million acres within the Basin by 1980. These agronomic, grassland, and woodland practices are also needed in conjunction with the structural measures, above and below the structure sites, and in areas of less pronounced flood danger (no structural site planned) to control the rate and amount of soil loss and water flow.

A positive approach toward conservation, preservation and improvement is needed in the minds of all of the local people if such improvements are to be accomplished. Watershed improvements are most successful when both the urban and rural peoples, both the farmer and the factory workers, are sufficiently motivated to want to start and fully carry out suggested resource conservation measures. Local leaders will need to show financial and resource savings and scenic betterment in both country and city situations in their discussions with the landowners and users.

3. RELATED LAND TREATMENT NEEDS

Proper management of the land, its use and treatment is needed for the general economic growth and betterment of the Basin. A land treatment program that will provide for continuous utilization of land resources to satisfy current needs and at the same time conserve this re-

source for future needs is essential.

Economic projections of crops, yields, and costs of production contained in this study are based on adequate land use, treatments, and management. Failure to follow adequate practices would, of course, substantially reduce projected yields and increase costs of prodtection. Therefore, a program of land treatment to reduce runoff, erosion, and sedimentation must be carried out.

The Michigan Inventory of Soil and Water Conservation Needs (CNI) shows projected future acreages of cropland, pasture, forest and woodland that will need conservation treatment.[1/] From the total of 2.1 million acres determined in 1958 to be in need of treatment by 1980 should be subtracted the amount of land treatment applied during the 10-year period, January 1958 through June 30, 1968 to determine the existing unfilled needs (Table 38, page 120).

a. Crop and Pastureland The CNI in 1958 identified 1,315,500 acres needed for cropland in 1980 as having one or more conservation problems and requiring conservation treatment in order to help meet future Basin crop needs. Over one-third of the original needs have been treated in the last ten years. Nearly 750,000 acres remain in need of treatment. Such treatment should be geared specifically toward significantly reducing wind and water erosion on 196,000 acres, excess water on or in 301,000 acres, and unfavorable soil conditions on 233,000.

About 184,000 acres were identified by the CNI as anticipated pastureland by 1980 that needed one or more pastureland treatment measures in 1958. There have been 35,000 acres successfully treated in the past decade. The acreage remaining in need of treatment is 149,000. The major needs are the establishment or re-establishment of vegtation on 75,500 acres and the improvement of vegetative cover on 54,100 acres of pasture. A total of 17,800 acres of wet areas need removal of excess water and protection of vegetative cover. Theatment measures to control soil erosion are also needed.

1/ CNI report estimates for 1975, which were used without adjustment in this study and assumed to be valid for the projection year of 1980.

TABLE 38 - Physical Land Treatment Needs

Land Use	Expected Acreage Use 1980 2/	Acreage Needing Treatment 1980 2/	Acreage Treated 1958-68 3/	Remaining Area Requiring Treatment By 1980
		(1,000 acres)		
Cropland	1,863.8	1,316	568	748
Pasture	269.8	184	35	149
Forest	643.6	490	19	471
Miscellaneous	388.7	107	4	103
Other 1/	392.5			
Total	3,558.4	2,097	626	1,471

1/ Includes urban built-up areas and water surface acreage.

2/ Based on 1958 CNI data.

3/ Applied from January 1958 to June 30, 1968.

b. Forest and Woodland Although the 1958 CNI identified 397,000 acres of forested land as needing one or more conservation measures, the present acreage projected for forested land use in 1980 in need of treatment is 471,000. The net gain resulted when the expected addition of idle, crop and pasture land acres to forest land uses overbalanced the acreage receiving treatment measures in the past decade.

Restocking or restoration to a productive condition will be needed on 139,800 acres of commercial forest land and idle open lands presently non-stocked by 1980. Protection from overcutting and excessive logging damage is needed on 346,200 acres. Grazing control is needed on 91,800 acres. Hydrologic stand improvement is needed on 107,200 acres.

Fire protection on forested lands is presently being adequately handled through the State Department of Natural Resources in cooperation with the U.S. Forest Service. In order to meet future protection requirements, there is a need for additional brush-type wildfire equipment and training in the volunteer fire departments, as well as additional prevention programs.

The future demands to convert forested lands will largely affect the farm woodlots, bottomlands, and similar areas now in sawtimber-sized trees. The production from these lands will be lost and should be replaced. The conversion process may be incomplete, isolating certain lands from reasonable access to timber-product markets. Forethought is needed during the planning for such conversion to avoid such difficulties.

There is a need for the protection and establishment of trees and forest cover in the metropolitan and suburban areas. Technical assistance and consultive and education services can assist regional and township planning commissions, planning boards, and city leaders, as well as local individual urbanites, in developing urban forest conservation and improvement practices.

c. Nonagricultural Land It is estimated that 103,000 of the acres projected to be classed as miscellaneous use in 1980 will need treatment. Generally, such treatment involves measures, such as grass and tree establishment, to control erosion. Water-controlling measures are also needed at various sites.

There will be increased pressure placed upon landowners to con-

vert their agricultural and forested lands into urban-industrial uses, such as highways, airports, and urban-suburban developments. The orderly conversion of crop and pasturland should be encouraged to prevent haphazard urbanization and excessive reductions in the better agricultural land.

More intensive use of cropland and woodland areas for recreation purposes is expected. Multiple use of such Basin lands when feasible for hiking, picnicking, hunting, and other natural resource-based recreation activities is necessary and desirable. Water-oriented outdoor recreation is an important part of the people's attraction to agricultural and forested settings. Although many locations have adequate resource conditions, the facilities need to be developed, improved, or made more available for public use. Long-range planning and direction is needed to help meet both the increasing future private and public recreation needs.

4. EROSION AND SEDIMENT PROTECTION

Protective measures are needed to control undue erosion occurring on nearly 350,000 acres of cropland, pasture and forest land in the Basin. Lack of such protection helps cause improper management of the water and related land resources and contributes to increasing sheet, rill, gully and streambank erosion.

Erosion control is most needed on open and untreated areas. If left unchecked, erosion causes considerable damage to agricultural crops, fields, fences, and building sites. Erosion control is also a consideration of improved forest management. Need of protective measures to control erosion affecting such nonagricultural land uses as highways cuts, unsurfaced roads, bridge embankments and approaches, road culverts, and business, residential, and other construction sites is markedly increasing. Some sections of streambanks in the Basin need erosion control practices to retard further, heavy soil losses and fouling of water quality.

Sheet erosion rates on Basin cropland soils need to be reduced to at least the maximum allowable "soil-loss tolerance" for each given acre.1/ Considering the Basin-wide average, this would involve a reduction from a weighted mean erosion rate 3.11 tons of soil loss per acre per year (t/a/y) to a soil-loss tolerance of 3.00 t/a/y for most of the soil associations in the Basin. Although this above difference may not be particularly significant, an examination of the various soil associations more strongly emphasizes the need to reduce cropland erosion. Soil Association 2, typically the Miami-Conover soils, occupying more than one-third of the Basin, has a markedly higher weighted mean erosion rate -- 4.26 t/a/y. Control of erosion is also needed on pasture lands even though the existing weighted mean erosion rates are much less than on cropland.

Erosion losses from soils on forested lands need to be reduced, ideally to approach geologic norms, to help improve the water quality in the Basin. Such reductions below the present erosion rate of 0.1 tons of soil loss per acre per year need to be part of a program of improved forest management, which would also include grazing control, tree planting and hydrologic cultural operations.

Control of erosion on nonagricultural lands is most needed on sites undergoing construction. Soil losses on ground left open during construction operations have been found to be 20 times greater than the average soil loss from all types of nonagricultural lands in varying degrees of development, according to a Southeast Michigan urban erosion study. Contractors and builders need to be convinced that practicing erosion-controlling operation during site development is much more effective than doing it at the very end.

1/ The term "soil-loss tolerance" is used to denote the maximum rate of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely. This rate is predicted through the Universal Soil Loss Equation and is usually expressed in terms of average soil loss per acre per year.

Unchecked erosion contributes to excessive sedimentation of waterways. Controlling soil losses is needed to help reduce the sediment discharge rates into streams, rivers and lakes. Heavy sedimentation cuts sown the use of such waters and affects their appearance.

More effective water-control measures are needed to contain sediment-laden waters during floodstage so the sediment deposits do not end up smothering crop and pasture lands, as well as hampering use of roadways, bridges, and other man-built structures. Sediment control is needed in forested areas to facilitate management operations and help preserve wildlife habitat and recreation opportunities. Excessive sedimentation negates the water-controlling effects that a covering of litter on the forest floor can bring.

5. POLLUTION CONTROL

Effective control of such water pollutants as waste materials, plant nutrients, exotic chemical sprays, and soil particles (suspended sediment) is a major need in the Basin. Treatment of already fouled waters is needed to sufficiently restore them to an acceptable condition for varied fish and wildlife populations and for recreational, industrial, and domestic uses. Further controls are needed to restrict these pollutants from entering and fouling presently clean waters.

Control of agriculture-related pollutants must be considered together with controls for municipal, industrial, mining, marine, and other types of pollution in developing an integrated effort for improving the soil, water and air resources of the Basin.

6. PRESERVATION OF ENVIRONMENTAL QUALITY

In the process of finding solutions to problems of water supplies, flooding, land use, erosion, sedimentation and pollution, care is needed to use methods and measures which also preserve or enhance the quality of the natural environment.

Water level fluctuations need to be regulated in controlled-situation sites to cut down excessive aquatic growth. The use of rapid drawdowns needs careful thought before implementing because of the barren banks that can quickly become exposed.

Land use problems can be solved in various ways. Care is needed to

use management methods that can reinforce and improve the beauty spots; e.g., avoiding abuse through over use of recreation areas, promoting forest management techniques that enhance the beauty of woodlands, the control of trash and waste material dumping into waterways and on rural scenic areas.

Control of the soil on the land is needed to help maintain a clearness and attractive coloration in the streams, ponds and lakes, encouraging a greater human use and appreciation of the water and related land resources in the Basin. Excessive sedimentation in reservoirs, waterways, and on land during flooding needs corrective measures that will restore the natural appearance of the resource as well as the effective usefulness of the site or structure.

A strong program is needed to stop the accelerating deterioration of the natural environment in and around areas of high population density. With continued delay, the costs of correcting such situations will be extremely high. In many cases correction will become impossible. A wide variety of technical disciplines, careful planning, continuing management, and strong community action needs to be involved. Without them in the right combination, public and private programs for planning and managing natural lands within the urban area cannot be successful.

7. ACCELERATED SOIL SURVEYS

Agricultural land is under increasing pressure from urban growth and expanding public facilities. The nearly irrrversible land use decisions which are being made daily require sound planning. A detailed soil survey is basic to the planning process. This inventory of our soil resources shows the location of different soils, describes their physical and chemical properties, and summarizes their limitations for various uses.

Approximately 2,500 acres in the Basin are being converted to urban uses annually. This acreage, will nearly double by the year 2020. This scope of development must be based on sound soil information.

At this time, eleven of the twenty counties with acreage within the Basin have soil surveys completed or scheduled for completion. There are no current plans for completing the detailed soil survey in the remaining nine counties. In these areas, the Soil Conservation Service will

continue to provide soil surveys to individual landowners for conservation planning. This will not, however, be sufficient to provide guidance for all anticipated land use decisions.

SECTION VI

EXISTING WATER AND RELATED LAND RESOURCE PROJECTS AND PROGRAMS

There are a number of projects and activities presently taking place in the Basin which are tended to help the people better manage their use of the natural resources. Some of the projects are part of broad programs carried out by State and Federal governmental agencies. County and city governments and private citizen groups work on localized aspects of these projects as well as on smaller projects of their own. The resource-improvement projects suggested by this study can supplement these existing activities.

1. USDA AGENCIES

Several USDA agencies carry out programs that provide both technical and financial assistance to help private landowners apply proper land use practices to their land. Some of the agencies direct similar resource-improvement programs on public-owned lands. Other agencies carry on research and provide technical information and support to these operations agencies.

a. Agricultural Research Service The Agricultural Research Service conducts research to provide a scientific basis and support for the land and water resource programs administered by operations agencies of the Department of Agriculture. Included are investigations on hydrologic performance of agricultural watersheds; erosion and sedimentation; moisture and water conservation; irrigation; drainage; hydraulics of water control structures and channels; soil properties, processes, and management; soil-water-plant relations; plant nutrition; practices and systems for preventing or controlling contamination of soil and water resources by agricultural chemicals and farm wastes.

b. Agricultural Stabilization and Conservation Service The Agricultural Stabilization and Conservation Services administeres the Agricultural Conservation Program and the Cropland Adjustment Program through which the Federal Government shares the cost of increasing the application of certain soil and water conservation practices. These practices help to reduce soil erosion and sedimentation, reduce runoff, and provide water storage funds for agricultural and other uses.

c. Economic Research Service The Economic Research Service is concerned with evaluating present and future production capabilities of American agriculture, both nationally and regionally. Research into the financial benefits that can be derived from adjusting resource use, adopting new technologies, and developing existing resources provides the means for evaluating future agricultural production and the need for water resource development. This information is readily available to farm operators and agricultural leaders for their use in future management decisions.

d. Farmers Home Administration The Farmers Home Administration has various loan provisions which affect the management and development of rural and urban water resources. These include: (a) watershed loans to local sponsors to help finance their share in PL-566 watershed projects; (b) loans to farmers to aid in applying conservation practices and in making improvements in farm operations; and (c) loans to public bodies for development of land and water for recreation, rural domestic water supply and waste disposal systems

e. Forest Service Forest Service programs include three major activities: cooperative state and private forestry programs, administration of the national forest program, and forest research. Each of these activities is directly related to the water resources.

(1) National Forests

Seven hundred acres of the Huron-Manistee National Forest extends into the Basin in Newaygo County. This area is part of the Rogue River Sub-basin. In addition, approximately 600 acres of federal land in the Lower Grand Sub-basin are in Land Utilization Projects which are under contract to soil conservation districts in cooperation with the Forest Service (Plate 1, Addendum). The multiple-use policy guides the use of these lands.

(2) Cooperative State and Private Forestry Programs

Watershed protection, fire control, pest control, and forest management programs on State and privately owned forest lands are being conducted by the Division of Forestry, Michigan Department of Natural Resources in cooperation with the U.S. Forest Service. Most of these programs make significant contributions toward the solution of water re-

source problems. The Forest Service also participates in several other programs including the Northern Great Lakes Region Program, resource conservation and development projects, and other river basin studies.

(3) Research

The Forest Service conducts research in the fields of watershed management, forest economics, and timber, recreation, and wildlife use of forested lands. Some of this research is carried out at various project locations in the experimental forests and watersheds of the State. The results obtained provide a basis for developing better resource management methods on forested lands of similar conditions in the Basin.

f. Soil Conservation Service The Soil Conservation Service is involved in several programs in the Basin.

(1) Technical Assistance to Soil and Water Conservation Districts

Soil Conservation Districts are locally organized, locally managed segments of State government. Through a Memorandum of Understanding, authorized under the Soil Conservation Act of 1935 (P.L. 46), individual SCD's can enter into an agreement with the SCS to receive technical asistance. The district landowners receive this information and assistance in resource conservation improvement from SCS technicians stationed at the county level.

The program of the districts involves conservation planning on all lands, assisting in the development of broad research plans, and the installation of land treatment and conservation practices. The practices are determined after full consideration of the soil capabilities and needs of the land.

There are 22 Soil Conservation Districts which are partly or wholly within the Basin.

(2) Watershed Protection and Flood Prevention (P.L. 566)

This program provides a project-type approach to soil and water resource development, use, and conservation. Proper land treatment is the basic element of watershed projects. Structural measures operate in conjunction with land treatment to achieve such project objectives as flood prevention, drainage, irrigation, recreation, and fish and wildlife improvement. Qualified local sponsors obtain Federal technical

and cost-sharing assistance for the installation of necessary works of improvement.

Two watershed projects have been completed within the Basin, and are contributing to improved water resource management. The Muskrat Creek Watershed, located in Clinton County includes 2200 acres of land treatment and 4.6 miles of multiple purpose (flood prevention and drainage) channel improvement. The Catlin-Waters Watershed, also located in Clinton County, includes 710 acres of land treatment and 4.3 miles of multiple purpose (flood prevention and drainage) channel improvement.

(3) Conservation Needs Inventory

A National Conservation Needs Inventory was made in 1958-60. A breakdown of this data was made both by state and county. Starting in 1967 this inventory was being updated and widened in scope to provide more current detailed data on land use and conservation treatment needs by soils on non-Federal rural land, and to obtain data on watershed project needs for both privately and publicly owned land in the United States.

The first phase covers the non-Federal rural land available for the production of food and fiber crops. This part of the inventory will show: (a) the acreage of land by uses and subdivisions as a basis for inventorying soil and water conservation needs; (b) crop and land uses by land capability classes and subclasses for cropland, pasture land, forested land, and other land.

The second phase covers the watershed project needs on all lands without regard to ownership. The inventory will show: (a) number and location of project-size watersheds, (b) kind and extent of watershed problems, (c) need for project action for all purposes eligible under PL-566, and (d) feasibility of the inventoried watersheds for project development.

(4) Northern Great Lakes Region Program

In 1963 the Secretary of Agriculture designated the counties of a 56-million acre area in the northern parts of Minnesota, Wisconsin, and Michigan, as the Northern Great Lakes Region (NGLR). Newaygo, Mecosta, and Muskegon Counties are part of the Michigan segment of the NGLR. Only the extreme southern parts of these counties are in the Grand River Basin.

Local leaders assisted in dividing the Region into 56 Broad Program Areas (BPA's). Those portions of the Basin in the Region are in Michigan BPA-14. Land in a given BPA has a similarity in the natural resources available and the problems involved in their wise and continuing use. Local leadership through the Soil Conservation District has taken the initiative in starting activities leading to improve resource use and development. They receive technical and financial assistance through USDA agencies, principally the Soil Conservation Service, in developing their resources for the greatest benefit to all.

(5) Other Programs

As of the end of the 1969 fiscal year, there were no Resource Conservation and Development projects being carried on within the Basin. Published soil surveys are available for Ionia, Montcalm, and Muskegon Counties. Soil surveys have been completed in Livingston, Ottawa, and Shiawassee Counties, but the reports have not yet been published. Progressive soil surveys are continuing in Clinton, Eaton, Gratiot, Ingham, and Washtenaw Counties. Scattered soil mapping for conservation planning is being conducted in the remaining counties.

2. OTHER GOVERNMENT AGENCIES

The Department of Agriculture is the only federal agency actively administering any public land in the Basin. This land is part of the Huron-Manistee National Forest. The rest of the Public owned land is under state, county, and municipal administration, which have various resource development programs. These governmental branches also have programs which provide guidance to private landowners in the development of their own land.

a. Michigan Department of Natural Resources The State has developed a number of public recreation, fish, and wildlife areas in the Basin which are managed by the Department of Natural Resources. As of June 30, 1968, they had built 1 state and 14 roadside parks on over 1,500 acres in 7 counties. There were 53 fishing access sites and 5 waterfowl flooding projects in 13 counties for the sporting public. The State owned nearly 63,000 acres in 14 designated state game areas located in parts of 10 counties. They had 3 state recreation areas in 4 counties; their

land ownership was over 22,000 acres. They maintain a 3,200-acre wildlife reaearch experiment station in parts of Clinton and Shiawassee Counties and a 200-acre state game farm in Ingham County.

Canoe trail routes have been established along most of the State's major rivers. In the Basin there are trails along the Grand, Maple, and Thornapple Rivers. Fully developed canoe trails will include periodic stopover sites having such facilities as boat launches, camp and picnic grounds, waste disposal places, and potable water supplies.

Color trails have been marked throughout the state to point out the best routes to travel to see the brilliance of the fall color changes in the wooded areas. Four of these trails pass through ten of the counties in the Basin.

The Division of Forestry of the Department of Natural Resource works with private landowners upon their request, to help them better manage their woodlands. There are about 37 area foresters assigned to cover the State of Michigan. Six of these men work in counties within the Basin. The foresters are available to provide forest management assistance for the wise management and protection of forest lands to assure maximum production of forest products and services and protection of the watershed. Some of them spend a portion of their time working on state forest lands. The U. S. Forest Service cooperates with the Division of Forestry by providing technical and/or financial assistance in watershed and forest management.

b. Michigan Cooperative Extension Service Three Extension Specialists (in Forest Management) of the Michigan Cooperative Extension Service serve the State as information and education specialists concerning forested areas. The Basin falls within the jurisdiction of the East Lansing-based forestry specialists. Their duties include responding to requests from private groups to lead tours and give talks that point out proper forest and woodland management techniques that can be practiced on private forested areas. The Extension Service program in Michigan is financed jointly through the State, the USDA, and Michigan State University.

c. Soil Conservation Districts The Soil and Water Conservation Districts, though classed as arms of state government, are organized on

a county basis. Property owners wishing to receive and put into practice technical information on the improved use of their resources can join these districts. They receive assistance from several of the USDA agencies toward their objectives.

d. County and Municipal Government Each county and its major municipalities have some programs involving resource improvement in their local areas.

(1) County Parks

Beside the state parks in the Basin, there are 81 municipal and county parks in 13 counties. Eight of these county and state parks, located in parts of Barry, Gratiot, Jackson, and Ottawa,Counties are designated as Michigan campsites. Each site provides from some to all of these facilites: swimming, fishing, boating and canoeing areas, boat launch sites, trailer parks, campstoves, water and electrical facilities, and waste disposal locations.

(2) County Drainage Districts

The drainage districts within each county have general programs of periodic maintenance and repair of the county drain ditches. The betterkept countrywide drain systems provide their landowners with favorable nearby access into which they can channel their excess water. No water management or conservancy districts have been established as yet in the Basin.

(3) Planning Commissions

A number of planning commissions are active within the Basin in preparing land development studies. The studies set forth the expected future population needs, then present a pattern of wise land use development designed to conserve and perpetuate the natural resources, yet meet the people's needs. Included are studies of transportation, water management, floodplain delineation, soils, and open space requirements.

County planning commissions have been established have been established in Jackson, Kent, Livingston, and Muskegon counties. The Kent-Ottawa Regional Planning Commission carries out planning activities for that two-county region. The former Tri-County Regional Planning Commission was established to carry out studies for Clinton, Eaton, and Ingham counties. Its activities have now been terminated and planning functions

are being carried out by each of the individual counties.

3. PRIVATE BUSINESSES

Two rural electric cooperatives, the Tri-County Electric and the Ottawa and Allegan, serve most of the rural areas of the Basin. Neither is carrying on any prominent land and water resource improvement projects or services at the present.

There are some private organizations at work which can further the cause of woodland management. The Tree Farm Program, sponsored by the American Forest Industries, offers public recognition to private forest land owners for their voluntary commitment to good forestry practices. Some forest-based industries have established their own management programs under which they will provide technical services to forest owners under contract for purchase of their timber products. Forest owners can also hire the services and technical assistance of private consultant foresters.

SECTION VII

POTENTIAL DEVELOPMENT AND SOLUTIONS TO WATER AND RELATED LAND RESOURCE PROBLEMS AND NEEDS

1. DEVELOPMENT POTENTIAL

a. Water Resources Projected water usage and related land resource requirements are dependent upon the physical potential for development and the relative costs of production with and without development.

Average annual runoff varies from approximately 7 to 12 inches in the Basin; however, some areas show a minimum runoff of about one inch. Average annual runoff is about 9.1 inches, which is about 2.7 million acre-feet available for capture to be used for agricultural and other purposes.

It is expected that much of the increase in irrigation will be supplied from ground water sources. A study by the U. S. Geological Survey shows a delineation of ground water availability classified in four catagories -- poor, fair, good, and excellent (Figure 8, page 153). In the "excellent" category, there are 988 square miles containing a supply sufficient to irrigate all of this area; however, it is probable that only enough wells could be developed to irrigate one-half of the area. There are 517 square miles of area classified as "good", and it is expected that wells could be developed to irrigate about 25 percent of this area. The remainder is classified as "poor" or "fair". In these areas, it is unreasonable to expect development of ground water sources for irrigation purposes except for localized situations.

Potential reservoir sites which offer attractive possibilities for public or private developments have been inventoried (Table 39, pages 136 thru 139 and Plate 4, Addendum). Public or private organizations could improve the water-oriented recreational opportunities by utilizing these reservoirs.

b. Land Resources The data on acreage with a physical potential for irrigation (Table 31, page 85) has been incorporated into the budgeting model, along with costs and returns of particular resource development activities, and an economic potential for development determined for irrigation and drainage.

TABLE 39 - Data for Potential Reservoir Sites

Grand River Basin

Structure Number	Drainage Area Sq. Miles	Drainage Area Acres	Maximum Development of Reservoir Sites 1/ Capacity Ac.Ft.	Capacity Inches	Pool Area Acres	Embankment Height Feet
UPPER GRAND RIVER SUB-BASIN						
9	48.4	30,980	19,900	7.7	1,600	31
10	25.0	16,000	4,300	3.2	510	28
60	35.0	22,400	12,300	6.6	2,230	25
130	5.3	3,405	1,010	3.6	170	31
131	13.0	8,346	15,120	21.7	1,780	35
135	3.2	2,050	2,480	14.5	250	38
138	4.0	2,542	5,720	27.0	540	35
141	7.4	4,740	10,400	26.4	1,400	26
142	3.1	2,000	4,510	27.0	360	44
143	3.7	2,370	3,410	17.3	530	-
144	14.8	9,477	11,700	14.9	980	48
146	4.0	2,540	2,050	9.7	180	35
PORTAGE RIVER SUB-BASIN						
124	18.2	11,330	3,200	3.4	715	19
125	21.7	13,900	7,370	6.8	1,120	25
170	8.2	5,200	1,000	2.3	200	20
171	30.1	19,250	7,800	4.9	2,200	-
THORNAPPLE RIVER SUB-BASIN						
24	50.0	32,000	10,500	3.9	870	46
25	26.0	16,640	19,500	14.1	940	60
29	31.0	19,840	15,100	9.1	1,060	48
31	6.0	3,840	9,600	30.0	630	62
32	32.0	20,480	25,000	14.6	1,900	53
35	13.0	8,320	11,600	16.7	570	52
37	24.0	15,360	23,300	18.2	1,920	49
71	31.0	19,840	25,000	15.1	1,400	52
172	15.6	9,973	3,420	4.1	650	22
174	71.7	45,930	25,000	6.5	5,500	29
175	3.4	2,170	1,710	9.4	160	-
177	23.5	15,056	18,080	14.4	1,690	33
178	28.8	18,400	23,650	15.4	2,040	36
179	11.2	7,208	14,090	23.4	1,150	48
180	9.1	5,842	7,760	15.9	750	39
182	6.8	4,360	1,230	3.4	110	38
185	4.5	2,930	2,410	9.9	190	-
186	2.5	1,646	3,040	22.2	140	75
187	3.8	2,451	770	3.8	70	-

1/ Maximum development limited to 300% of mean annual runoff, 25,000 Acre feet or site maximum.

TABLE 39 - Data for Potential Reservoir Sites (Continued)

Structure Number	Drainage Area Sq. Miles	Drainage Area Acres	Maximum Development of Reservoir Sites Capacity Ac.Ft.	Capacity Inches	Pool Area Acres	Embankment Height Feet
THORNAPPLE RIVER SUB-BASIN (continued)						
190	2.9	1,863	210	1.4	20	-
194	28.9	18,524	3,630	2.3	270	37
196	5.7	3,660	2,500	8.2	210	-
197	3.7	2,375	3,740	18.9	470	-
200	5.6	3,641	4,470	14.7	280	-
201	2.9	1,896	2,260	14.3	70	38
202	3.1	2,017	2,070	12.3	180	-
203	7.3	4,626	1,620	4.2	130	-
204	15.9	10,214	7,490	8.8	540	35
205	5.4	3,470	960	3.3	120	26
206	6.4	4,145	3,510	10.1	240	-
207	11.2	7,174	2,240	3.8	300	25
214	3.1	2,013	5,040	30.0	230	41
MIDDLE GRAND RIVER SUB-BASIN						
40	23.0	14,720	20,000	16.3	590	110
41	28.0	17,920	9,100	6.1	430	78
43	53.0	33,920	19,300	6.8	980	90
44	25.0	16,000	9,200	6.9	430	76
219	10.9	6,945	3,760	6.5	320	39
220	6.8	4,350	430	1.2	70	-
222	11.4	7,295	3,250	5.3	190	66
223	8.4	5,380	520	1.2	40	-
226	4.8	3,130	3,250	12.5	250	-
227	9.8	6,325	3,590	6.8	260	60
230	4.5	2,990	-	-	-	-
231	9.5	6,065	-	-	-	-
232	-	-	-	-	-	-
234	10.9	7,020	1,400	2.4	100	50
235	30.8	19,720	3,700	2.2	190	70
236	31.8	20,367	12,500	7.3	350	114
237	4.7	2,990	2,030	8.1	80	-
238	3.5	2,230	4,990	26.8	210	-
239	17.1	10,997	4,520	4.9	220	52
240	9.3	5,935	8,970	18.1	300	90
241	7.7	4,950	4,880	11.8	250	-
242	3.8	2,420	6,060	30.0	220	-
243	4.1	2,640	210	1.0	20	-
RED CEDAR RIVER SUB-BASIN						
56	32.0	20,480	25,000	14.7	2,220	18
100	9.8	6,243	12,600	24.2	1,230	-
101	32.5	20,796	25,000	14.4	2,030	-
102	26.7	17,051	25,000	17.6	1,950	42
103	21.9	13,974	25,000	21.5	1,850	42

TABLE 39 - Data for Potential Reservoir Sites (Continued)

Structure Number	Drainage Area Sq. Miles	Drainage Area Acres	Maximum Development of Reservoir Sites 1/ Capacity Ac.Ft.	Capacity Inches	Pool Area Acres	Embankment Height Feet
LOOKINGGLASS RIVER SUB-BASIN						
148	15.2	9,713	2,500	3.1	400	-
149	9.8	6,252	3,670	7.1	530	28
151	4.1	2,620	1,310	6.0	190	-
153	49.9	31,905	10,805	4.1	1,400	32
154	3.7	2,390	3,160	15.9	490	-
155	5.5	3,550	600	2.0	80	-
158	9.8	6,326	2,000	3.8	330	-
STONEY CREEK SUB-BASIN						
162	20.1	12,873	12,340	11.5	1,380	38
168	4.5	2,910	3,420	14.1	330	-
MAPLE RIVER SUB-BASIN						
67	82.8	53,000	14,130	3.2	375	51
105	4.0	2,525	4,200	20.0	420	45
107	10.1	6,481	3,000	5.6	500	25
108	7.4	4,733	7,880	20.0	740	38
109	29.3	18,760	6,250	4.0	280	35
110	11.1	7,135	8,210	13.8	546	33
115	5.3	3,421	1,990	7.0	350	35
119	10.0	6,400	- 1/	-	-	-
121	12.0	7,680	-	-	-	-
122	16.0	10,240	-	-	-	-
FLAT RIVER SUB-BASIN						
244	16.1	10,311	1,030	1.2	150	25
246	8.9	5,754	460	1.0	80	24
247	3.7	2,426	2,360	11.7	240	-
248	4.1	2,650	6,620	30.0	270	-
249	8.1	5,160	2,500	5.8	240	20
255	48.4	31,005	-	-	-	-
257	36.1	23,142	-	-	-	-
258	63.6	40,716	-	-	-	-
259	27.6	17,704	-	-	-	-
261	6.0	3,840	2,350	7.3	130	-
ROGUE RIVER SUB-BASIN						
264	5.7	3,620	1,330	4.4	90	-
268	6.7	4,330	7,330	20.3	450	-
269	16.2	10,400	8,260	9.5	520	50
270	25.3	16,167	13,720	10.2	800	600
271	1.9	1,269	3,810	36.0	170	-
272	7.3	4,695	9,500	24.3	480	-
273	12.5	8,021	22,010	32.9	1,100	55
277	3.9	2,490	4,660	22.5	220	-
278A	9.2	5,886	17,570	35.8	680	90

1/ Lack of Topo. Coverage.

TABLE 39 - Data for Potential Reservoir Sites (Continued)

Structure Number	Drainage Area Sq. Miles	Drainage Area Acres	Maximum Development of Reservoir Sites Capacity Ac.Ft.	Capacity Inches	Pool Area Acres	Embankment Height Feet
LOWER GRAND RIVER SUB-BASIN						
12	29.0	18,560	6,200	4.0	580	32
15	45.0	28,800	4,800	2.0	320	45
16	45.0	28,800	5,800	2.4	390	40
17	41.0	26,240	6,000	2.7	640	35
18	35.0	22,400	9,300	5.0	710	34
64	14.0	8,960	4,600	6.2	430	42
280	13.2	8,462	-	-	-	-
281	17.9	11,447	-	-	-	-
282	2.1	1,341	3,360	30.0	120	-
284	9.3	5,941	14,850	30.0	470	110
285	2.0	1,295	3,240	30.0	140	-
288	-	-	-	-	-	-
293	2.1	1,364	3,410	30.0	125	-
296	3.5	2,250	2,650	14.1	130	-
297A	10.7	6,823	5,400	9.5	520	32
303	3.4	2,170	2,450	13.6	200	-
305	5.7	3,664	1,770	5.8	150	-
308	5.4	3,462	2,020	7.0	190	-
309	25.8	16,557	21,880	15.8	1,360	52
310	6.7	4,265	1,660	4.7	130	-
311	4.5	2,940	1,650	6.7	110	-
312	2.1	1,315	2,100	19.2	130	-
313	4.0	2,540	1,420	6.7	80	-
314	5.1	3,290	1,100	4.0	130	-
315	7.5	4,790	3,050	7.6	450	30
316	21.1	13,530	3,195	2.8	400	33
317	29.1	18,600	7,850	5.1	970	37
318	28.4	18,205	7,740	5.1	750	37
320	11.0	7,075	6,470	11.1	580	38
321	18.6	11,920	2,340	2.4	150	52
322	6.5	4,145	630	1.8	50	-
323	4.8	3,118	5,750	22.1	600	-
324	4.1	2,600	1,150	5.3	100	-
325	4.2	2,710	1,260	5.6	120	-
326	3.8	2,430	1,050	5.2	100	-
328	2.3	1,495	920	7.4	80	-
330	3.0	1,940	1,480	9.1	120	-
331	8.0	5,100	3,630	8.5	250	-
332	9.2	5,907	6,050	12.3	420	38
333	4.1	2,620	2,360	10.8	200	-
336	3.3	2,140	1,020	5.7	90	-

Cropland available for irrigation of major crops without further investment in resource development is estimated at about 1.5 million acres in 1980. The acreage available is expected to decrease to approximately 1.2 million by 2020, due to urban-related uses and increased acreage of fruits and vegetables. Row crop acreages available for irrigation are 72 percent of the total cropland acreage in 1980, but rise to 75 percent in 2000 and to 80 percent by 2020.

Projections show, however, that an economic potential of only 28,050 acres, 36,682 and 48,044 acres under irrigation is anticipated for the years 1980, 2000 and 2020. This would require 17,882 acre-feet, 24302 and 32,048 acre-feet of water on an average annual basis.

Potato and vegetable crops have the greatest potential for irrigation.

Total acreage of cropland available for crop production and having a drainage potential is projected to be nearly 284,000 in 1980 (Table 41, page 142). Drainable cropland declines by 17,600 acres between 1980 and 2000, and by 25,000 acres from 2000 to 2020.

Much of the non-producing cropland identified in Table 12, page 53, and not required to meet major crop production demands, is ideally suited to recreational use. Because of its relatively lower productivity or higher costs of production it has limited use in agriculture unless demands rise sufficiently to force it into production. But, the very attributes that make it less desirable for crop production are sought after in recreational areas. These lands are rolling to very hilly with low and marshy areas interspersed and the soils range from sandy loams to coarse sands with a problem of stoniness in places. Care should be taken not to commit these lands irrevocably to some other use as production pressures against the cropland base in later projection years forces the use of some of these lands to meet agricultural needs. In the interim, however, the use of such areas for recreation or wildlife habitat should be encouraged.

Most of the forested land has a high potential to improve hydrologically. There are some poorly drained areas involving bogs and impermiable soils which restrict hydrologic movements.

TABLE 40- Surface Water Potentials, Recreation Potential and Estimated Recreation Impact by Subareas

Subareas	Reservoir Sites 1/ (Number)	Surface Water Potentials 2/ (Acres)	Upstream Total Potentials 3/	Activity Breakdown Camping 4/ (Annual Occasions)	Day-Use 5/	Estimated Recreation Impact 6/ (Dollars)
Jackson	10	12,265	3,066,250	214,637	2,851,612	2,062,971
Lansing	19	26,621	6,655,250	465,867	6,189,382	4,477,650
West Central	21	10,920	2,730,000	191,100	2,538,900	1,836,744
Grand Rapids	15	10,490	2,622,500	183,575	2,438,925	1,764,418
Subtotal	65	60,296	15,077,380	1,055,179	14,018,819	10,141,783
Basin	84 7/	106,366 7/	26,591,500	1,861,405	24,730,095	17,890,761

1/ Does not include 11 projects in Livingston, Muskegon and Shiawassee counties, not considered in sample area.
2/ Acreages represent maximum possible areas for inventoried SCS (upstream) impoundment sites.
3/ Recreation potential is based on projects of 250 annual occasions of the five activities considered (swimming, boating, waterskiing, camping and picnicking) for each acre of surface water available.
4/ Based on projections indicating that camping demand totaled seven percent of the total.
5/ Based on projections indicating that demand for day-use activities (swimming, boating, waterskiing and picnicking) constituted about 93 percent of the total.
6/ Total figure for camping and day-use activities based on average away from home expenditures per person per day of $4.10 for camping and $1.50 for day-use activities.
7/ Includes all inventoried SCS and Corps of Engineer projects except for 11 projects as explained in footnote 1 above.

TABLE 41 - Acreage of Cropland Available for all Crops With A Physical Potential for Drainage, 1980, 2000 and 2020 1/

Soil Association	All Crops		
	1980	2000	2020
		(1,000 Acres)	
1	11.6	10.8	10.5
2	88.7	81.0	72.8
3	65.8	58.9	53.1
4	54.2	49.2	44.7
5	25.2	29.4	26.8
6	8.2	7.5	6.8
7	29.9	29.7	26.8
Total	283.6	266.5	241.5

1/ Represents the available cropland base for the production of all crops which still require drainage, as reported in the CNI. This is the physical potential for drainage after the removal of minor crops and urban related acreages.

These areas are relatively insignificant.

The potential reservoir sites are projected to supply a water recreation potential amounting to slightly over 15 million annual occasions (Table 40 , page 141).

c. Physical Potential of Treatment Measures Part of the land treatment improvements needed include measures to control and reduce sheet erosion on Basin lands. Recommended land treatment measures are aimed at improving the use and conservation of all natural resources. They will result in increased, long-term production of economic returns and aesthetic values. They will, at the same time, reduce sheet erosion rates considerably below their present level.

Such measures can potentially decrease erosion on cropland from a Basin-wide average of 3.11 tons of soil loss per acre per year t/a/y to between 1.00 and 2.00 t/a/y. Erosion rates after treatment on Soil Associations 1, 2, and 3 are estimated at 1.00, 1.50 and 1.00 t/a/y. Reduced erosion rates on Associations 4 and 5 are estimated at 2.00 t/a/y. Although the saving in tons of soil lost is less than

two when compared to Basin-wide averages, the expected saving in lands in Association 2 (occupying one-third of the Basin) is nearly three t/a/y.

Reductions below the present sheet erosion rates are potentially possible in forested lands through various management and improvement. The present precipitation-runoff curve number (RCN) can be expected to be reduced from 58.9 to 54.7. This number indicates the relationship of rainfall to runoff; a RCN of 100 would mean a total storm discharge with no water being retained on or in the ground. Based on a 100-year frequency storm of 4-day duration, the runoff expected from forested land that is fully treated can be reduced by 18 percent. This would affect the erosion rates by reducing the present rate of 0.1 tons of soil loss per acre per year to approximately 0.06 t/a/y. Such hydrologic improvements can be expected to prevent the movement of over 15,000 tons of soil from forested lands yearly. These erosion rate estimates are based on expected land treatment measures and on the soil loss predictions obtained through use of the Universal Soil Loss Equation.

2. SOLUTIONS TO RESOURCE PROBLEMS AND NEEDS

a. Alternative Solutions In solving problems and meeting resource needs in the Basin, several kinds of improvements are often available as possible choices. These alternative choices consider both physical and institutional improvements. In solving the major problems, several of the listed alternatives will likely be used. Consideration of these alternative choices and the selection of one or more kinds of solutions rests primarily with the local people with action carried out mainly through local units of government.

(1) Structural Alternatives

Needs can be met, in part, through use of the following kinds of structural improvements.

(a) Water Supply

1 Ground water development

2 Surface water development

3 Water importation from Great Lakes

(b) Flood Prevention

1 Retarding structures

2 Channel improvements

3 Diversions

4 Levees

(c) Related Land

1 Erosion control structures

2 Water control structures

(d) Erosion and Sedimentation Control

1 Stream bank stabilization

2 Erosion control structures

(e) Water Quality

1 Sediment settling basins

2 Sewage treatment plants

3 Reservoirs for low flow augmentation

(f) Environmental Quality

1 Reservoirs for recreation uses

2 Erosion control structures

(2) Nonstructural Alternatives

Needs can be met, in part, through the use of the following kinds of nonstructural improvements.

(a) Water Supply

1 Land use and management for water yield

2 Artificial recharge

3 Land acquisition

4 Institutional constraints

(b) Flood Prevention

1 Floodplain zoning

2 Flood forecasting - warning - evcuation systems

3 "Flood-proofing"

4 Floodplain acquisition

5 Review of new construction proposals

6 Land use and management to control runoff

(c) Related Land

1 Land use zoning and regulation
2 Tax relief
3 Land acquisition
4 Obstruction or hazard removal
5 Purchase of easements or development rights
6 Land and water management

(d) Erosion and Sedimentation Control

1 Land use and management
2 Stream bank stabilization
3 Land acquisition
4 Land use zoning and regulation
5 Tax relief

(e) Water Quality

1 Land use zoning and regulation
2 Land treatment and management to control runoff
3 Removal of waste solids
4 Standards and regulations
5 Legal measures -- enforcement

(f) Environmental Quality

1 Land use zoning and regulation
2 Land acquisition
3 Recreational easements
4 Urban forestry
5 Tax incentives
6 Land use and management
7 Better use of vegetation

b. Physical Measures The actual application of the alternatives selected to meet the Basin needs involving use of specific physical measures or practices. Just as in the listing of alternative solutions, where some are shown as helping solve several problems, the application or specific land treatment and water control practices can also affect several problems. Such practices can be separated into water resource

practices and land practices. But just as important as the actual practices are the effects and their interplay that the application of them will have in meeting Basin needs. Such effects will influence the selection between various alternatives.

(1) Water Supply Improvement

Practices that can be used in the development, containment, and utilization of Basin water supplies are varied. They include stream channel and bank improvement, stabilization and protection, along with channel obstruction clearing and snagging. Water supply improvement also involves spring and well development. Irrigation improvements include surface and subsurface systems, sprinkler systems, pits or regulating reservoirs, pipelines, canals, laterals, ditches, ditch linings, and water management and spreading operations. Pipelines for watering help in livestock management.

Water-holding improvements include containment and diversion dams, storage reservoirs, fish ponds, wildlife ponds, dikes and levees. Water control practices include retaining structures and pumping plants, as well as floodways, floodwater diversions and retarding structures. Nonagricultural water control structures include sediment settling basins and debris catchment basins.

Other types of ground and surface water development provide significant alternatives to reservoir storage development for the creation and maintainance of municipal or industrial water supplies. This is particularly true in the western part of the Basin where pipelines to Lake Michigan may be shared by several communities, or where ground water aquifers are abundant and may support enough wells to serve an entire regional system.

The development of artificial underground aquifers and the greater use of natural aquifers may be other feasible alternatives to reservoir storage. Best results can be expected in those areas where the permeability or thickness of overburden is such that adequate infiltration rates can be achieved. Diverting streams through such areas or creating natural pools, like the City of Kalamazoo has done, may be other acceptable alternatives. Wells drilled in close

proximity to these areas of improved water infiltration and retention or along streams might withstand higher pumping rates than wells in locations lacking access to such ground water supplies. Water supply options such as these may be profitably employed in many Basin areas, and the use of them will definitely be needed in those areas without adequate reservoir sites.

(2) Land Use and Management

Through resource planning, choices between alternative combinations of land use and erosion control practices may be made, making it possible to use the land within its capabilities and applying conservation treatment within its needs. Such planning of the resource is essential to provide for its present utilization while conserving the resource for future needs.

These practices include physical alteration of the land and improvements in managing its resources under the major kinds of land use, agricultural, forestry, pasturing, recreational, and wildlife.

Agricultural practices include crop rotation, crop residue, contour farming, minimum tillage, mulching, strip cropping, and cover or green manure cropping. Livestock use practices include pasture and hayland planting, management and renovation; rotation and deferred grazing, stock trail development, and trough or watering tank construction.

Vegetative practices include the sodding and/or seeding of grassed waterways and various critical areas (pond edges, road cuts, urban construction sites, steep hillsides and other areas quite vulnerable to erosion). Hedgerow planting, field windbreaks, and development of field borders are "encouragement" practices, while controlled burning and brush control are "discouragement" practices. Forest management improvement practices to help upgrade the hydrologic quality and economic value of forested lands in the Basin include site preparation, tree planting, selective harvesting, and such cultural activities as thinning, weeding, and sanitation cuts. Protection against woodland grazing is also practiced.

Wildlife practices involve wetland and wildlife habitat management, developing wildlife watering facilities, fish stream improvement and fish pond management. Recreation activities include site stabilization and improvement, recreation land shaping, and trail, walkway, and roadway development.

Drainage activities involve field drainage and hillside ditches, as well as tile drains of all kinds. Land moving practices include grade stabilization structures, diversions, chiseling and subsoiling, land grading and smoothing, and various kinds of terraces.

Practices such as mulching, contouring, sodding, seeding, tree planting, etc. also have application on urban and other nonagricultural lands.

The ways in which land is utilized and managed has a very direct effect upon the broad range of problems identified in the Basin. Agricultural activities may be enhanced by clearing woodland, fence rows, or stream banks. In the process, though, hydrologic conditions may be altered, fish and wildlife habitat disrupted, and the rates of soil and stream bank erosion multiplied. The removal of vegetative cover during periods or urban, industrial, commercial, or transportation development contributes significant quantities of sediment to streams and low-lying areas. Such development affects the ecological systems, altering plant, fish, and wildlife habitats and populations, and imposes a negative influence upon the environmental quality of an area.

But, while there are obvious remedies to the resource problems, it must be recognized that they are associated with a very real cost. In addition to the direct costs of proper resource management to control these problems and the operational costs of carrying out land use changes, there are indirect costs as reflected in possible reduced income and the foresaking of existing comforts and other anticipated benefits.

The management of land for multiple objectives may only be economically beneficial up to a point. Beyond that point the secondary uses, which are economically less desirable despite being

more desirable in terms of the resources, begin to compete with the primary use. The returns to the primary use will decline, and the total economic returns may even decline.

Conservation measures that will maintain soil productivity, retain the soil on the land, slow down the movement of surface water, and improve the general appearance of the landscape need greater emphasis. Planting or retaining certain tree and shrub combinations along highways and within metropolitan areas will provide screenings for residential, industrial or auxiliary uses, and will enhance environmental quality. Planting or retaining cover as a buffer strip along streams will help filter overland flows entering the streams while providing fish and wildlife habitat.

c. Nonphysical Solutions Many of the nonstructural alternatives listed earlier in this section appear to be possible solutions for helping meet a wide variety of the water and related land resource needs. Among them are a number of nonphysical alternatives requiring social and institutional action for implementation.

With the exception of certain legal alternatives, adoption of most of the nonphysical measures identified here would require initiating action on the part of local governmental units. Costs associated with carrying out any of the alternatives would depend entirely upon the proposed use to be made of the specific alternative and the extent of adoption. Finances are discussed in conjunction with programs that include any of the measures.

(1) Zoning and Regulation

The use of zoning and regulation to influence future land use presupposes, at the very least, some conceptual plan and desire for a more orderly process of development and change. Zoning permits the community to control the use of land in public interest by limiting the number of uses and the ways of resource development available for the landowner to apply. In its extreme, it may restrict him to a single choice or a single development method.

Most early uses of zoning were designed to control the location of undesirable development, to segregate development requir-

ing different levels of utility services, and to restrict certain uses from a particular place. The latter use, includes restricting detrimental development on the floodplain and is embodied in the recently enacted State floodplain control act. Zoning measures may also be adopted that provide for protective action, in addition to their preventative language. They could be designed to protect and perpetuate such extensive uses as agriculture, forestry, recreation, fish and wildlife, or any combination of these. Such measures would help conserve the natural resources despite increasing urbanization, and would contribute to better environmental quality, increase the recreational opportunities, and provide a means to placate the psychological feeling of social overcrowding. Restricting and/or removing unsuitable land development from the floodplain cuts down excessive erosion and removes a direct source of possible pollution to the area's waterways.

Another useful application of zoning in the Basin is the designation of appropriate areas for use as open space and greenbelt sites, and to provide certain kinds of rural experience for a growing, urban population. This would reserve certain areas for parks, golf courses and natural trails, and would provide for agricultural units of sufficient size to be economically viable. It would serve to break up the monotony of large urban complexes and would create a more varied, less artificial environment.

Regulation may take the form of control, enforcement of standards, or review of intended use. State and local ordinances or enabling legislation could be adopted to encourage certain uses, restrict others, or to establish tolerance limits for acceptable use. Such regulations have already been established at some level for public health reasons. Greater enforcement of these and additional regulations might result in an acceptable alternative to applying several structural measures in the solving of a given problem.

New or increased use of the water resource requires approval of the Michigan Water Resources Commission. This same review and approval power might be extended to a state or regional land use

authority which would evaluate possible problems associated with major changes in land use. Consideration of the overall effects of a new highway program, the location of a major airport or industrial complex, and the location of a large feed lot or food processor might come before this body. This same "authority" could be given the power to encourage certain interim measures that would prevent such problems from occurring.

(2) Corrective Measures in the Floodplain

Corrective or remedial measures may prove expedient, in the shortrun, for floodplains of the Basin that are already developed. These could take the form of: (1) setting up flood warning systems; (2) establishing evacuation procedures for particularly critical reaches; (3) requiring "flood proofing" of all future buildings to be built upon the floodplain; and/or, (4) requiring compulsory flood insurance with sufficiently high premiums so that floodplain inhabitants would bear a significant share of the burden. If a conscious policy of allowing all kinds of floodplain use and development is followed, future occupants should be made perfectly aware of the risks involved in locating there and encouraged to apply some kinds of preventative or protective measures on their own.

(3) Land Acquisition

Public purchase of land in fee simple ownership or only partial acquisition provides the most direct mechanism for the public interest to find expression in meeting a variety of water and related land resource problems in the Grand River Basin. Strategically located purchases of public land along troublesome reaches of the main stem or tributaries of the Grand could help to alleviate the need for flood protection, control a likely source of sediment, and provide habitat for fish and wildlife. At the same time, it could enhance the quality of the environment, provide for recreation, and, if tied in with the purchase of development rights or recreation easements along the streams, could preserve much of the river system for a variety of recreational pursuits.

On lakes and at certain points along streams, the purchase of public access points could be used for boat launching sites or bathing and picnicking facilities. Such purchases have been made to some extent by the State, but county or community purchases for these purposes should also be encouraged.

Within municipalities with river frontage, consideration should also be given to the purchase of public development sites which include portions of the floodplain. These floodplain areas could be kept undeveloped and used for parks, nature walks, or just to contribute to the area's environmental quality.

(4) Tax Policies

Tax policies, which favor particular land uses and encourage their adoption while, at the same time, discouraging other uses, can be effective tools for helping solve some of the problems associated with water and related land resource uses. Michigan has two yield tax laws, one applicable to commercial forests and one to woodlots (areas up to 40 acres). These tax incentives are favorable to the long-term commitment necessary in the production of forest products. Under the "Commercial Forest Reserve Act" an annual specific tax of from 5 to 10 cents per acre is imposed, and a yield tax of 10% is imposed upon the stumpage value of all forest products cut. Under the "Woodlot Act", property tax may not be valued at more than $1 per acre, and a 5% yield tax is imposed upon the stumpage value of timber cut. Impact of these laws is undetermined in the Grand, but widespread use should be encouraged.

The retention of certain types of agricultural activities near urban areas could be encouraged by tax incentives. These could be made conditional upon the planting of favorable wildlife cover and/or the permitting of public hunting on the land.

SECTION VIII

OPPORTUNITIES TO ACCOMPLISH RESOURCE IMPROVEMENTS

In formulating plans for resource improvements, consideration has been given to many structural and non-structural alternatives. The following recommendations indicate those measures which may be implemented through USDA programs. Many other alternative solutions, including tax policies, water quality control, and floodplain management, are equally important, and depend upon state and local initiative.

1. USDA RESOURCE IMPROVEMENT PROGRAMS

The several USDA agencies now operating within the basin will assist in fulfilling the needs outlined in Section V. This will be accomplished in part through existing programs; but some problems will require new authorizations in order to fully meet the needs for resource management.

a. Watershed Protection and Flood Prevention (PL-566) This program provides a project-type approach to soil and water resource development, use, and conservation. Proper land treatment is the basic element of watershed projects, and is considered as the initial increment in project formulation. Structural measures operate in conjunction with land treatment measures to achieve project objectives.

This study has identified 14 watersheds with potential for development within the next 10 to 15 years (Table 42 page 155), Table 43, page 156, and Plate 3, Addendum). These watersheds may be developed if sponsored by qualified local groups. The evaluation of these watersheds was based on the maximum potential development. The scope and purpose of these projects will be dependent upon the desires of the local sponsoring organizations.

Investigations also identified 26 watershed with potential for future development (Table 44, page 157, Table 45, page 158, and Plate 3, Addendum). These would be justified primarily through bringing new land into agricultural production, and may become feasible with a growing demand for good and fiber in the future. There may be other small projects which are feasible, but which were not identified by the broad screening techniques used in this study.

TABLE 42 - SUMMARY OF UPSTREAM AREAS WITH POTENTIAL FOR EARLY DEVELOPMENT (10-15 YEARS) - PHYSICAL DATA

Grand River Basin, Michigan

Watershed Name	Evaluation Unit	Watershed Area 1/	Flood Plain Area	Flooding and Inadequate Drainage Area		Channel Improvement	Structure Site
				Mineral Soil	Organic Soil		
		(sq. Mi.)	(Acres)	(Acres)	(Acres)	(Miles)	(Number)
Twin Lakes Drain	UG-5	5.4	--	265	797	5.4	
Freeman Marsh Drain	UG-5	8.0	--	--	1,223	7.2	
Huntoon Lake	UG-5	11.6	--	511	696	6.4	
Perry Creek	UG-5	10.4	--	1,536	1,715	5.3	
Bly Lake	UG-8	11.7	--	1,302	1,367	8.8	
Eaton Rapids	UG-8	13.6	--	1,321	492	8.3	
Upper Columbia Creek	UG-9	18.3	--	1,527	1,019	7.6	
Portage River	P-1,2,3,4	185.8	7,100	3,420	4,940	21.5	171 5/
Prairie Creek	MG-6	46.0	--	2,386	615	8.4	
Libhart Creek	MG-7	17.1	--	1,039	637	8.4	
Upper Maple River 2/	M-1,2,3,4 5,8,9,10,11	312.0	16,500	24,470	4,390	54.2 3/	109-110 4/
Hayworth Creek	M-12	93.5	--	2,432	1,950	14.0	
Stony Creek	S-1,2,3,4, 5,6	178.1	2,227	7,221	1,024	42.1	
Rogue River	R-1,2,3	37.9	3,100	--	3,100	10.6	
TOTAL		949.9	28,927	47,430	23,965	208.2	

1/ This area is also included in flooding and inadequate drainage area.
2/ Data from PL-566 Watershed Work Plan, both East and West, July 1969.
3/ In addition to channel improvement, there are two multiple-purpose structures, 14.4 miles of dike construction, and four drainage pumping stations.
4/ Multiple-purpose structures - flood prevention and recreation.
5/ Single-purpose fish and wildlife structure.

TABLE 43 - Summary of Upstream Areas With Potential for Early Development (10-15 Years) - Economic Data

Grand River Basin, Michigan

Watershed Name	Average Annual Benefits 1/					Total 2/ Installation cost	Average 3/ Annual Installation cost	Benefit Cost Ratio
	Flood Prevention							
	Flood Damage Reduction	More Intensive Land Use	Drainage	Recreation	Total			
Twin Lakes Drain	--	3,100	3,101	--	6,201	90,700	5,672	1.09:1
Freeman Marsh Drain	--	4,042	4,042	--	8,084	120,000	7,486	1.08:1
Huntoon Lake	--	4,292	4,293	--	8,585	110,600	6,861	1.25:1
Perry Creek	--	5,000	5,000	--	10,000	105,300	6,537	1.53:1
Bly Lake	--	5,889	5,889	--	11,778	148,700	9,238	1.27:1
Eaton Rapids	--	5,032	5,033	--	10,065	140,900	8,759	1.15:1
Upper Columbia Creek	--	5,869	5,870	--	11,739	119,300	7,669	1.53:1
Portage River	143,941	--	93,869	10,000 6/	247,810	3,892,250 7/	228,832	1.08:1
Prairie Creek	--	8,100	8,101	--	16,201	230,500	14,482	1.12:1
Libhart Creek	--	5,162	5,163	--	10,325	128,100	8,342	1.24:1
Upper Maple River 4/	184,100	115,600	115,600	1,495,600	2,190,700 5/	11,287,400	817,059	2.70:1
Hayworth Creek	--	25,575	25,575	--	51,150	531,700	32,290	1.58:1
Stony Creek	9,496	27,009		--	63,514	801,200	53,510	1.19:1
Rogue River	--	38,750	38,750	--	77,500	1,075,650	60,348	1.28:1
Total	337,537	253,420	347,295	1,505,600	2,723,652	18,782,300	1,267,085	2.15:1

1/ Price base-adjusted normalized prices.
2/ Price base-1967
3/ Amortized at 4 7/8 percent interest over a 50-year period, includes O&M cost.
4/ Data from Watershed Work Plan, both East and West - July 1969.
5/ Includes $279,800 for local secondary benefits.
6/ Fish and wildlife benefits.
7/ Includes $155,900 installation cost for structure No. 171 (fish and wildlife)

TABLE 44 - Summary of Future Upstream Areas With Potential For Future Development - Physical Data
Grand River Basin, Michigan

	Evaluation Units	Watershed Area	Flood Plain Area 1/	Flooding and Inadequate Drainage Area Mineral Soil	Flooding and Inadequate Drainage Area Organic Soil	Channel Improvement
		(sq. mil)	(acres)	(acres)	(acres)	(miles)
Snyder & Wheeler Drain	UG-4	9.2	-	471	920	10.7
Rives Junction	UG-6	8.0	-	307	653	5.3
State	UG-6	4.0	-	128	32	1.4
Berry Lake	UG-5	2.7	-	-	242	1.1
Pleasant Lake	UG-5	5.3	-	-	544	4.3
Whitney Drain	UG-5	3.8	-	400	-	4.2
Leslie	UG-5	7.5	-	511	696	6.4
Darling Christie Drain	UG-5	4.5	-	288	154	2.6
Lanes Lake	UG-5	4.7	-	256	-	2.0
Willow Creek	UG-7	16.6	-	510	1,892	12.1
Sandstone Creek	UG-6	31.6	-	1,059	2,709	23.1
Tompkins	UG-6	6.8	-	416	205	5.4
Spring Brook	UG-8	35.3	-	662	2,326	23.3
Bateese Creek	P-3	18.0	-	390	1,570	5.3
Upper Cedar River	RC-1	20.1	-	610	3,460	17.6
Winegar	RC-3	5.7	-	171	968	4.9
Middle Cedar River	RC-3	28.7	93	859	4,862	37.6
Randal	RC-4	3.4	63	242	730	4.5
Grant	RC-4	4.8	88	344	1,040	3.0
Brown	RC-4	4.8	88	344	1,040	5.7
Mud Creek	RC-14	28.3	-	1,830	986	18.1
Lookingglass River	L-1,2,3,4	187.0	-	5,188	10,617	75.0
Pewamo	M-14	7.5	-	1,035	55	6.9
Penny Creek	F-3	18.9	-	1,041	1,000	7.3
Hemmingway Lake	F-3	2.2	-	110	82	1.0
Black Creek (Montcalm & Kent)	F-4	45.6	-	3,968	3,968	14.2
TOTAL		515.0	332	21,140	40,751	303.0

1/ This area is also included in flooding and inadequate drainage area.

TABLE 45 - Summary of Future Upstream Areas With Potential
For Future Development - Economic Data
Grand River Basin, Michigan

(Dollars)

Watershed Name	Average Annual Benefits 3/ More 2/ Intensive Land Use	Changed Land Use	Total	Total Installation Cost 4/	Average Annual Installation Cost 5/	Benefit Cost Ratio
Snyder & Wheeler Drain	1,422	11,105	12,527	180,400	11,150	1.12:1
Rives Junction	732	6,745	7,477	90,100	5,580	1.34:1
State	240	1,760	2,000	24,400	1,511	1.32:1
Berry Lake	-	2,400	2,400	19,500	1,208	1.99:1
Pleasant Lake	96	6,280	6,376	77,900	4,925	1.29:1
Whitney Drain	1,800	3,100	4,900	70,900	4,399	1.11:1
Leslie	3,212	4,212	7,424	110,600	6,861	1.08:1
Darling Christie Drain	1,446	1,840	3,286	44,900	2,782	1.18:1
Lanes Lake	120	2,775	2,895	35,100	2,176	1.33:1
Willow Creek	4,884	20,975	25,859	207,600	13,132	1.97:1
Sandstone Creek	4,728	35,415	40,143	486,100	30,543	1.31:1
Tompkins	600	6,095	6,695	91,700	5,696	1.18:1
Spring Brook	2,130	34,780	36,910	468,700	29,189	1.26:1
Bateese Creek	3,660	9,250	12,910	104,700	6,774	1.90:1
Upper Cedar River	17,360	53,450	70,810	378,000	24,096	2.94:1
Winegar	4,889	8,579	13,468	79,800	3,432	3.92:1
Middle Cedar River	24,561	163,001	187,562	988,550	62,385	3.00:1
Randal	5,782	14,112	19,894	78,000	4,840	4.11:1
Grant	8,229	20,084	28,313	52,000	3,232	8.76:1
Brown	8,229	20,084	28,313	97,500	6,048	4.68:1
Mud Creek	15,555	24,650	40,205	415,700	25,511	1.57:1
Lookingglass River 1/	16,405	574,297	590,702	1,169,200	76,850	7.68:1
Pewamo	4,350	4,120	8,470	118,200	7,440	1.14:1
Penny Creek	833	15,150	15,983	61,000	4,557	3.50:1
Hemmingway Lake	243	1,980	2,223	17,200	1,064	2.08:1
Black Creek (Montcalm & Kent)	2,925	44,595	47,520	312,400	19,622	2.42:1
TOTAL	134,431	1,090,834	1,225,265	5,780,150	365,003	

1/ Data from major and local drainage report, SCS-June 1961
2/ Composed of Agricultural water management (Drainage) benefits and floodwater damage reduction benefits that have not been separated. 3/ Price Base-Adjusted normalized prices. 4/ Price Base-1967.
5/ Amortized at 4 7/8 percent interest over a 50-year period, includes O & M cost.

(1) Non-structural Improvements

A program of non-structural improvements is essential to the proper functioning of a watershed project. Land treatment measures will reduce surface water runoff, erosion, and sedimentation which would adversely affect the construction, operation, and maintenance of the proposed structural works of improvement.

These measures will be applied through an accelerated program of assistance to watershed landowners through the local soil conservation districts and the Michigan Department of Natural Resources. This accelerated program will be conducted in addition to the conservation programs available under other authorities.

The land treatment measures will be installed by the landowners. The estimated costs are total installation costs and do not reflect cost-sharing assistance which may be available through other programs.

Accelerated technical assistance will be provided by the Soil Conservation Service, and the Michigan Department of Natural Resources in cooperation with the Forest Service, in the 14 potential watershed areas proposed for early action at an estimated cost of $800,000 and $191,700 respectively (Table 46, page 160).

(a) Cropland and Pasture Land Treatment The proper treatment of cropland and pasture land in watershed projects will help control erosion and eliminate unfavorable soil conditions.

Cropland treatment will involve: (1) water control measures, such as terraces, waterways, and field diversions; (2) measures to protect the soil from erosion and to increase infiltration rates, such as strip cropping, contouring, cover crops, grass and legume rotation, minimum tillage, and management of crop residues; (3) farm drainage systems; (4) supplemental irrigation supplies from farm ponds; (5) gully control measures; and, (6) establishment of grass or trees on some areas of presently cultivated land. Within the 14 potential watersheds, 107,600 acres of cropland will be adequately treated at an estimated installation cost of $5,664,300.

TABLE 46 - Cost of Accelerated Land Treatment Program within the 14 Potential Watersheds proposed for Early Action Grand River Basin, Michigan

Watershed	Watershed Area	Land Treatment Installation Cost 1/				
		Cropland	Pasture	Forest	Misc.	Total
	(Acres)	(Dollars)				
Twin Lakes	3,456	38,100	7,500	2,100	1,900	49,600
Freeman-Marsh	5,120	56,400	11,000	1,900	2,900	72,200
Huntoon Lake	7,424	81,800	16,000	700	4,200	102,700
Perry Creek	6,656	73,400	14,000	3,400	3,700	94,500
Bly Lake	7,488	82,500	16,200	2,800	4,200	105,700
Eaton Rapids	8,704	95,900	18,800	3,500	4,900	123,100
Upper Columbia	11,712	129,000	25,000	7,000	6,600	167,900
Portage River	118,912	1,408,100	156,000	61,500	66,900	1,692,500
Prairie Creek	29,440	324,400	63,500	20,800	16,600	425,300
Libhart Creek	10,944	124,200	23,600	5,400	6,200	159,400
Upper Maple	195,460	1,342,800	107,900	17,500	20,100	1,488,300
Hayworth Creek	59,840	266,900	31,500	2,600	9,700	310,700
Stony Creek	113,984	1,373,500	145,900	36,100	64,200	1,609,700
Rogue River	24,256	267,300	52,300	26,900	13,700	360,200
Subtotal	603,396	5,664,300	689,500	192,200	225,800	6,771,800
Technical Assistance						
Soil Conservation Service						800,000
Federal-State Cooperative Forestry						191,700
Total						7,763,500

1/ Price Base - 1967

Pasture land treatment measures include pasture and hayland planting, pasture and hayland renovation, and farm drainage systems. Within the 14 potential watersheds, 20,000 acres of pasture land will be treated at an estimated installation cost of $689,500.

(b) Forest Land Treatment The treatment program on forest land will involve greater participation by State and Federal Agencies in assisting private land owners with the management of their land. The hydrologic condition can be improved or protected by proper planning, by using the forest land as a renewable resource, and by applying various treatment measures. These measures include: tree planting; hydrologic stand improvement, including thinnings, weedings, and sanitation cuttings; protection from livestock grazing; and, protection from overcutting and excessive logging damage. Forest fire protection will be in effect throughout the Basin, furnished by the Michigan Department of Natural Resources in cooperation with the U.S. Forest Service under the Clarke-McNary Cooperative Fire Control Program. Within the 14 potential watersheds, 12,600 acres of forest land will be adequately treated. This figure includes multiple treatment of these acres. The total accumulative area of individual measures to be applied is 27,200 acres at an estimated installation cost of $192,200.

(c) Miscellaneous Land Treatment Treatment of miscellaneous land is needed to control erosion and reduce sedimentation. Generally this treatment will involve establishment of grasses and trees. Within the 14 potential watersheds, 8,400 acres of miscellaneous land will be adequately treated at an estimated cost of $225,800.

(2) Structural Improvements

Normally not all watershed needs can be met solely by land treatment. Problems such as flooding and imparied drainage usually require structural measures for adequate relief. In the watershed program, waterflow control measures are planned to operate as a system in conjunction with land treatment measures.

Floodwater retardation is the primary consideration in designing a system of waterflow control measures. Channel improvement, floodways, or diversions are considered supplementary to floodwater re-

PROTECTING THE LAND

Grass waterways carry water safely from the field.

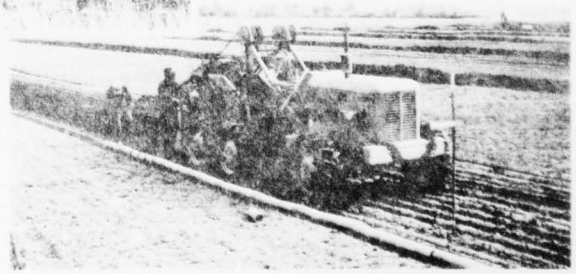
Windbreaks help control wind erosion.

Stripcropping protects fields against erosion.

A flood-retarding reservoir releases runoff slowly to prevent flooding.

WATER CONTROL

A drop structure helps prevent gullies.



Tile drainage improves agricultural efficiency.

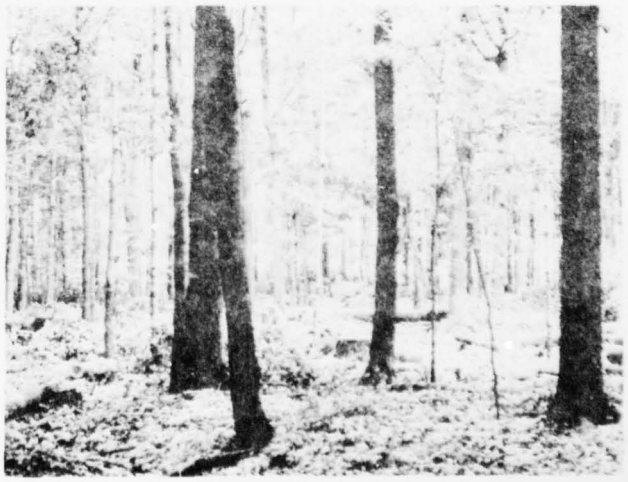
FOREST MANAGEMENT

Tree planting adds to our forest resource and helps control erosion.

Landowners are given technical assistance on forest management.

Fencing protects forest land from livestock grazing.

Selective cutting on overstocked land brings added income and improves the remaining stand.

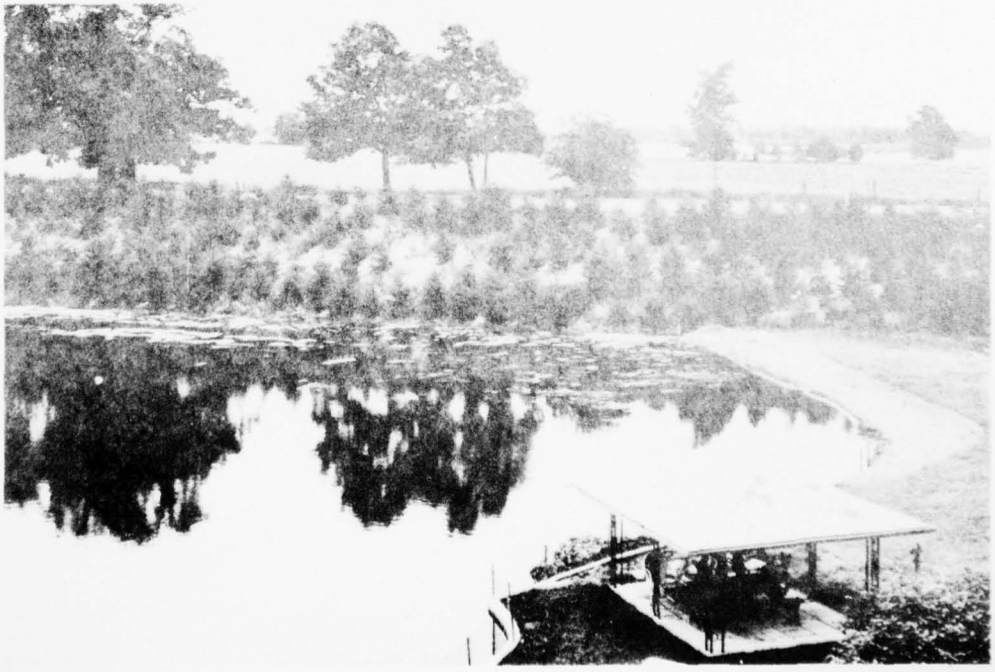


NONAGRICULTURAL IMPROVEMENTS

Sodding, seeding, and a concrete chute control erosion on this urban site.

Sodding roadbanks following construction helps prevent erosion.

This well-planned pond provides beauty and recreation.



tardation except where necessary to achieve project objectives at a reasonable cost.

The primary watershed needs in the Basin are flood control and improved agricultural drainage. These problems, as well as the general lack of adequate floodwater retention sites, require that channel improvement be utilized for waterflow control. Within the 14 potential watersheds, 208.3 miles of multiple purpose (flood prevention and drainage) channel improvement are proposed(Table 42, page155).

In addition, two multiple purpose structures are proposed in the Upper Maple River Watershed. These structures will operate in conjunction with channel improvement to reduce flooding, and will also provide surface water area for recreational use.

Structure 109, with a recreation pool of 235 surface acres, will be managed for extensive use with fishing as the major activity. Peak daily use is expected to be 3,200 visitors. Structure 110 will have a recreation pool of 471 surface acres. The primary activities will be swimming, picnicking, camping, boating, hiking, active games, and nature study. Peak daily use is estimated to be 20,500 visitors. These developments, located in the Lansing Subarea, will fill a need for water-related outdoor recreation facilities in the area of greatest demand.

The installation cost of these proposed structural measures within the 14 potential watersheds is estimated to be $18,782,300 (Table 43, page 156). Under provisions of the Watershed Protection and Flood Prevention Act (PL-566), qualified local sponsors would be eligible for technical assistance for the design, and cost-sharing assistance for the construction, of these structural measures.

b. Other Non-structural Improvement Programs The needs for resource improvement go beyond the scope of assistance available under the Watershed Protection and Flood Prevention Act. The remaining needs will be met through a varity of non-structural programs. Much of the needed action may be accomplished through existing programs; but new legislation will also be needed to adequately meet the needs of the Basin.

(1) Land Treatment Measures

Conservation treatment of the land is required to reduce erosion and sedimentation, control problems caused by excess water, im-

prove unfavorable soil and cover conditions, and improve water quality. The practices used to accomplish these goals will be similar to those outlined previously, and will be installed by the landowners and operators. Application of these practices will permit continuous utilization of the land for current needs while conserving this resource for future requirements.

(a) Current Programs USDA programs are currently making vital contributions to resource improvements in the Basin and will continue to help meet future needs (Table 47, page 164).

1 Cropland and Pasture Land

The basic vehicle for accomplishing adequate treatment of these lands is the Soil Conservation Act of 1935 (PL-46). Under this authority the Soil Conservation Service provides technical assistance to landowners and operators through the local soil conservation districts for planning and installation of land treatment measures.

Through this program, continued at its current rate of accomplishment, it is estimated that 145,000 acres of cropland and 15,000 acres of pasture land will be adequately treated by 1980.

2 Forest Land

Technical assistance for the protection and management of forest land is provided by the Michigan Department of Natural Resources, in cooperation with the U.S. Forest Service under the Cooperative Forest Management Program (CFM). At its current rate of accomplishment, this program will provide adequate treatment of 20,000 acres of forest land by 1980.

3 Miscellaneous Land

Treatment of miscellaneous land, generally with the establishment of grasses and trees, is accomplished through the PL-46 and CFM programs. At current levels, these programs will provide adequate treatment for 3,000 acres by 1980.

(b) Accelerated Land Treatment Program Current land treatment programs will fall far short of the 1980 needs within the Basin. Even with consideration of the PL-566 program, an estimated 1,139,400 acres would still require treatment by 1980 (Table 47, page 164). Included in this total are 502,700 acres located in the drainage areas of the

several multiple-purpose structure sites recommended in the Comprehensive Basin Plan of Development.

TABLE 47 - Non-structural Resource Improvements
Grand River Basin, Michigan

Land Use	Area Requiring Treatment by 1980 1/	Estimated Accomplishments		Residual Needs
		PL-566 Program 2/	Other Current Programs 3/	
			(1,000 acres)	
Cropland	748.0	107.6	145.0	495.4
Pasture Land	149.0	20.0	15.0	114.0
Forest Land	471.0	12.6	20.0	438.4
Miscellaneous	103.0	8.4	3.0	91.6
TOTAL	1,471.0	148.6	183.0	1,139.4

1/ From Table 38, page 120.

2/ To be applied in the 14 potential watersheds.

3/ To be applied from July, 1968 to December, 1980 in the PL-46 and CFM programs.

TABLE 48 - Recommended Accelerated Land Treatment Program
Behind Multiple-Purpose Structures
Grand River Basin, Michigan

Land Use	Land Treatment Acreage[1]	Installation Cost
	(Acres)	(Dollars)[2]
Cropland	255,000	12,529,000
Pasture Land	27,300	1,401,900
Forest Land	33,900	1,391,600
Miscellaneous	16,400	520,100
Sub Total	332,600	15,842,600
Technical Assistance Cost		
Soil Conservation Service		1,734,000
Federal-State Cooperative Forestry		995,500
Sub Total		2,729,500
TOTAL COST		18,572,100

1/ Includes multiple treatment of these acres.

2/ Price Base 1967.

It is recommended that an accelerated land treatment program be initiated in order to more adequately fill the gap between 1980 needs and accomplishments, and to help protect the proposed multiple-purpose structures from untimely deterioration due to erosion and sedimentation. This program will apply the necessary treatment on an estimated 332,600 acres at an estimated cost of $18,572,100 (Table 48, page 165).

This program will concentrate its efforts on those Basin lands outside the potential watershed project areas and behind the proposed multiple-purpose structures. It will provide for 66 percent of the remaining 1980 needs behind those structures. Land treatment measures will be applied by the landowners and aoperators. The estimated costs are total installation costs and do not reflect cost sharing assistance which may be available through other programs.

Accelerated technical assistance will be provided by the Soil Conservation Service, and the Michigan Department of Natural Resources in cooperation with the Forest Service, at an estimated cost of $1,734,000 and $995,500 respectively.

It is anticipated that this program will operate through the soil conservation districts, and through the existing federal-state cooperative forestry programs.

1 Cropland and Pasture land

These lands will be treated to control erosion and eliminate unfavorable soil conditions. An estimated 255,000 acres of cropland and 27,300 acres of pasture land will be adequately treated at an installation cost of $12,529,000 and $1,401,900 respectively.

2 Forest Land

Protective and improvement measures will be applied on areas where the hydrologic condition of the land is or may be impaired. At an estimated 33,900 acres of forest land will be adequately treated. This figure includes multiple treatment of these acres. The total accumulative area of individual measures to be applied is 90,500 acres at an installation cost of $1,391,600. To help implement the cooperative forestry programs, it is recommended that the Federal Government

cost-share 80 percent of both the technical assistance costs with the state, and the installation costs with private landowners. This may require additional authorizations and new cooperative agreements between State and Federal Governments.

3 Miscellaneous Land

Treatment of this land will help to control erosion and reduce sedimentation. As estimated 16,400 acres of miscellaneous land will be adequately treated at an installation cost of $520,100.

(2) Environmental Enhancement in Urban and Built-Up Areas Through Soil, Forest, and Water Conservation

A technical assistance program for urban areas is recommended in order to protect soil and water resources, and to provide an opportunity for man to live in harmony with his natural environment. These goals may be achieved through proper land use planning designed to reduce soil erosion, help maintain water quality, reduce flood damages, improve vegetative cover, and enhance natural beauty. This program will provide assistance to planning boards, community leaders, and developers in formulating and implementing effective land use plans.

Proper interpretation of soil surveys will be provided to indicate the best development sites, and to help avoid problems of poor drainage, unstable soils, and severe erosion hazards. Recommendations for good land use will include methods of controlling excessive erosion will occur despite the most conscientious application of protective measures, the goal will be to prevent controllable erosion and keep sediment production to a minmum. This will not only protect the development site itself, but also prevent sedimentation and degradation of surface waters. Since much of the most favorable land is already developed, the use of soil surveys and soil conservation practices will become even more important in the future.

Pressures for floodplain use will increase with expanding population and continued economic growth. Future flood damages will be minimized only by plans and policies which recognize existing and potential flood hazards. Technical assistance will be provided to identify floodplain areas, and to aid in the development of prudent floodplain management programs.

Vegetative cover, including trees, shrubs, and grasses, established, retained, or improved in the metropolitan areas will provide natural beauty, recreation opportunities, and environmental enhancement. This program will furnish technical assistance for the development and maintenance of forests, nature areas, parks, open spaces, buffer zones, and greenbelt areas.

Assistance will include the identification and location of suitable areas to be retained for: 1, Community and school forests - to provide areas for aesthetics, recreation, and outdoor classes involving nature study and conservation education; 2. Vegetated buffer zones or screening strips - to isolate housing or industrial developments and for highway beautification, and; 3. Infiltration zones or sediment traps along waterways and roads - to retard surface runoff, erosion, and sedimentation. Advice will be available to improve tree stands and plant development to enhance recreation opportunities, wildlife habitat, nature studies, and sylvan aesthetics. Technical services will be provided for the control of insects, plant diseases, nonstructural fires, animal damage, and pollutants in forests, parks and greenbelt areas.

The program should be a local - State - Federal cooperative program involving the U.S. Department of Agriculture, the State of Michigan, Soil Conservation Districts, and other local units of government.

It is recommended that a 10-year, $800,000 urban soil and water conservation program be initiated to meet problems of poor land use and erosion in urban areas throughout the Basin. This program will be implemented through the Soil Conservation Districts in cooperation with the Soil Conservation Service.

It is recommended that a 10-year, $600,000 urban and community forestry assistance program be initiated in the Grand River Basin with emphasis placed on the Grand Rapids and Lansing areas. The Forest Service will be assigned leadership in the forestry program in cooperation with the Michigan Department of Natural Resources.

(3) Accelerated Soil Survey

Soil surveys have been used to guide land use and management decisions on farms and in forests for many years. These same principles of managing soil and water can be applied to urban development problems. The soil survey describes soil limitations for building sites, onsite sewage disposal, road construction, recreation development, and other uses. It may also be uses to locate potential sediment source areas, and as a tool for flood plain delineation.

Completed and currently programmed soil surveys cover eleven of the twenty counties with acreage within the Basin. The Soil Conservation Service is conducting soil surveys for conservation planning in the remaining nine counties. This level of survey activity will not be sufficient to provide for all of the needs of the expanding urban areas.

An accelerated program is recommended which will complete the soil survey throughout the Basin by 1985. A total area of 1,172,800 acres will be surveyed through the National Cooperative Soil Survey at an estimated total cost of $751,000. Early emphasis should be given to the expanding Grand Rapids and Jackson areas.

c. Economic and Social Assistance Programs Several current USDA programs provide financial and technical assistance to help satisfy economic and social needs. These programs will be beneficial in implementing resource improvements within the Basin.

(1) Land Use Programs

Two programs are available which provide financial assistance to encourage the proper use and treatment of the land. They are administered by the Agricultural Stabilization and Conservation Service.

(a) Agricultural Conservation Program This program provides cost-share assistance to farmers in implementing soil, water, woodland, and wildlife conservation practices on farmlands now in agricultural production.

This cost-share assistance will be vital in accomplishing the necessary land treatment as previously outlined. It is recommended that additional ACP funds be made available to implement

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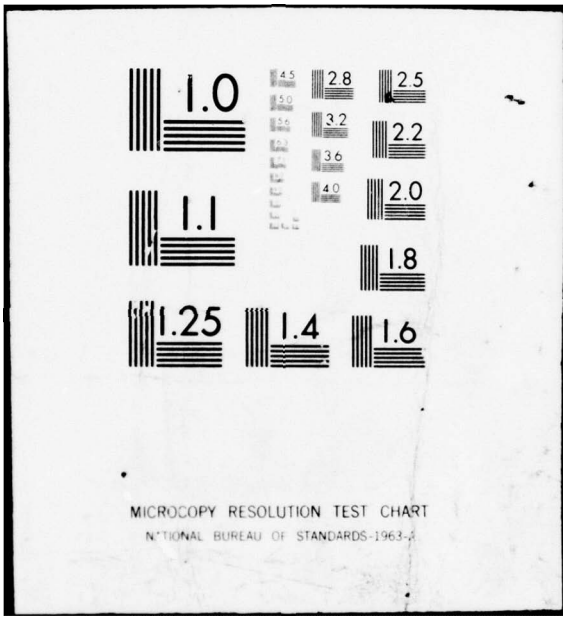
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the application of land treatment measures under the PL-566 program, and also under the accelerated program outside the watershed project areas. Without this additional assistance, the established 1980 land treatment goals may not be met.

(b) Cropland Adjustment Program This program helps farmers divert cropland to conservation uses for periods of five to ten years. Participants receive adjustment payments related to the value of crops normally produced on the land, and cost-share payments for needed conservation measures. Participants who permit free public access to CAP land for fishing, hunting, hiking, and trapping may get an additional per-acre payment.

The program also shares the cost with local, State, and other government agencies for establishing conservation practices on non-farm cropland to preserve open spaces and natural beauty, develop wildlife and recreation, and prevent air and water pollution.

The Greenspan provisions of this program offer: (1) financial assistance to city, town, county, or state governments, or to Federal agencies in acquiring cropland for preserving open spaces and natural beauty, for developing wildlife or recreational facilities, or for preventing air or water pollution, and (2) cost-share aid in establishing land conservation practices that will establish, protect, and conserve open spaces, natural beauty, wildlife, or recreational resources.

This program will encourage the application of needed land treatment measures and the use of the land within its natural limitations. It will also help meet the needs for non-agricultural uses of land and related water resources.

(2) Loan and Development Programs

Several programs administered by the Farmers Home Administration provide loans to qualified individuals and organizations for a variety of purposes related to farm and rural development. These programs may be helpful in meeting needs in the areas of land use and treatment, water supply, water quality, and non-agricultural water and related land use.

(a) Farm Ownership Loans This program provides farm

ownership loans and technical management assistance to operators of family farms. The purposes for which these loans may be used include:

1 Provide water facilities.

2 Provide basic soil treatment and conservation measures

3 Improve, establish or buy a farm forest enterprise.

4 Finance recreational enterprises to supplement farm income.

(b) Financial Assistance to Small Farms and Rural Groups This program makes loans and grants to public and nonprofit organizations primarily serving rural residents to plan and develop domestic water supply and waste disposal systems in rural areas.

Loans may also be made to install or improve drainage and irrigation facilities; establish recreational facilities, establish soil and water conservation measures, shift land use to grazing, wildlife, recreation areas, and forests.

(c) Other Loan Programs The FHA administers other loan programs which may provide assistance in certain situations. Briefly these are:

1 Loans for Forestry Purposes

2 Loans for Recreational Purposes

3 Operating Loans

4 Rural Housing Loans

(3) Educational Programs

The Cooperative Extension Service provides educational programs based on local needs in the broad fields of agricultural production and marketing, resource development, home economics, and youth development. Two of these programs will be particularly helpful in implementing proposals for resource improvements within the Basin.

(a) Agricultural Production and Marketing This program provides educational and technical assistance to help farmers, producers, and marketing firms apply new technological developments enamating from agricultural research. Through its assistance to farm operators the

program emphasizes good financial and resource management, and encourages proper land use and treatment. This will support the efforts of other agencies to achieve application of the necessary land treatment measures.

(b) Community Resource Development This program provides educational, organizational, and technical assistance to communities in developing their natural, economic, and human resources. This program may provide assistance to communities in solving the several non-agricultural needs within the Basin.

(4) Rural Development

Representatives of several agencies of the Department of Agriculture are organized for Rural Development at the State level. Members include a representative of the Forest Service, Soil Conservation Service, Farmers Home Administration, Rural Electrification Administration, Agricultural Stabilization and Conservation Service and the State Cooperative Extension Service. These agencies work closely with State and local people in support of comprehensive planning and development. They also maintain contact with other agencies in order to help extend their programs to rural areas.

2. COORDINATION WITH OTHER AGENCIES

Implementation of some of the USDA programs as previously outlined will require coordination and cooperation with other governmental agencies.

Local initiation and sponsorship is needed for the development of PL-566 projects. Soil conservation districts and drainage districts have sponsored previous watershed projects within the Basin, and are expected to assist in the development of the proposed projects.

Project formulation in the Hayworth Creek, Stony Creek, and Portage River Watersheds will require cooperation with the Michigan Department of Natural Resources in evaluating structure sites for recreation or fish and wildlife purposes. These single purpose structure sites may also included in the Comprehensive Grand River Basin Plan.

Further coordination with the Crops of Engineers will be needed in the Portage River Watershed since a proposed Crops structure on the

Grand River near Rives Junction will affect drainage upstream on the Portage River. Proposals for a dam with pumping facilities at the confluence of the Grand and Portage need additional cooperative study.

Soil conservation districts will share the responsibility for implementing portions of the current and accelerated land treatment programs. Active leadership will be required to insure that the treatment goals are met. The Michigan Department of Natural Resources will also have responsibilities in the land treatment program through federal-state cooperative forestry agreements.

Coordination of other governmental agencies, private groups, or individuals will need to be developed as appropriate to the particular program involved.

3. REMAINING NEEDS

The needs outlined in Section V are in many cases beyond the scope of current and proposed USDA resource improvement programs. Planning and implementation of measures to meet these needs should consider the assistance available through other governmental and private sources.

a. Flood Prevention and Drainage Many areas in the Basin which have floodwater and agricultural drainage problems are excluded from consideration as potential watershed projects because such resource improvements cannot be economically justified. The areas generally have one or more of the following shortcomings: (1) lacking sufficient size, (2) not currently being devoted to crops, or (3) having tributaries entrenched within relatively narrow floodplains. These physical factors severely limit the area's economic potential of development for agricultural use. This limitation influences the benefit: cost ratio sufficiently to reduce it below the minimum level for consideration as a potential watershed project.

b. Land Treatment The application of land treatment measures will be accomplished through current programs, and through accelerated programs, within and outside the 14 potential watershed areas. This combination of effort will be significant in meeting the 1980 needs, though some land will still require treatment (Table 49, page 174). Consideration should be given to long term land use and treatment contracts to

facilitate further acceleration in the application of needed non-structural resource improvements. With some acceleration of current programs after 1980, it is estimated that 85 percent of the remaining land treatment needs can be satisfied by 2020.

TABLE 49 - Accomplishments and Remaining Needs of Non-Structural Resource Improvements by 1980

Grand River Basin, Michigan

Land Use	Area Requiring Treatment by 1980 1/	Estimated Accomplishments 2/	Remaining Needs	Estimated Accomplishments as Percent of total 1980 Needs
		(1,000 acres)		(percent)
Cropland	748.0	507.6	240.4	68
Pasture Land	149.0	62.3	86.7	42
Forest Land	471.0	66.5	404.5	14
Miscellaneous	103.0	27.8	75.2	27
TOTAL	1,471.0	664.2	806.8	45

1/ From Table 38, page120.
2/ Accomplishments of PL-566, other current programs, and accelerated program, 1968 to 1980. From Table 47, page 164 and Table 48, page 165.

c. Recreation One potential watershed project (Upper Maple River) in the Early Action Program offers the possibility of multiple purpose structures with recreation developments. While these developments will provide recreational opportunities for many people, they will fall far short of meeting the Basin's total needs for water related outdoor recreation areas.

A number of the inventoried reservoir sites have a high potential for development into water areas for recreation. Several of these are in the potential watershed areas and could be developed as single purpose sites with limited Federal assistance. But many of the others are not located in any potential watershed project, either those proposed for development by 1980 or for later years. Other governmental programs, at federal, state and local levels, should be considered to assist in development of the non-watershed area projects. Some improvement projects may best be handled by private groups, businesses or individuals.

SECTION IX

IMPACT OF USDA RESOURCE DEVELOPMENT PROGRAMS

Development programs of conservation measures will have a marked effect upon solving the resource problems in the Basin. Their impact may be stated quantitatively in some cases, while other effects can only be described in general terms. These latter include biological and environmental effects which are nevertheless considered significant.

1. PHYSICAL AND BIOLOGICAL EFFECTS

a. Hydrologic Conditions Current and accelerated land treatment programs will improve the hydrologic condition on a total area of 664,200 acres by 1980, 1,171,200 acres by 2000, and 1,346,000 acres by 2020. Adequate treatment of these lands will reduce the volume and rate of storm runoff thereby reducing peak flows and potential flooding. Good soil cover conditions will increase rainfall infiltration, thus creating a more uniform base flow in the streams and contributing to the recharge of ground water aquifers.

The development of 14 watershed projects in the Early Action Program will provide improved water management for areas which are presently affected by flooding and impaired drainage. Two potential reservoir sites will provide a total of 3,500 acre-feet of floodwater storage, and 650 acres of surface water for recreational use. Also included are 208 miles of channel improvement which will provide flood prevention and improved drainage for 71,400 acres.

Relatively large areas with serious overland flooding problems are found in the Upper Maple River, Portage River, and Stony Creek watersheds. Nonstructural and structural improvements in these areas, proposed for Early Action, will reduce average annual acres flooded from 23,000 to approximately 2,000. This represents a 91 percent reduction in area flooded.

b. Related Land Conditions The use and treatment of the Basin's land determines to a large extent the nature and seriousness of erosion and resulting sediment problems. Continuing efforts to encourage proper land use and management will lead to reduced sediment quantities entering the streams.

Complete soil surveys will insure that nearly irreversible land use decisions are based on accurate, up-to-date soils information. Thus all uses of the land will be planned to take advantage of natural soil characteristics with full knowledge of the limitations for various purposes. This will protect the high investments associated with urban development, and promote wise use of our soil resources.

Many of the soils in the Basin contain considerable amounts of clay and silt. Much of the eroded material from these fine-textured soils is carried considerable distances downstream before it is deposited. While in suspension, this material adversely affects water quality, making it undesirable for many uses. Upon deposition, the sediment contributes to high nutrient levels in surface waters, destroys fish habitat, and causes loss of capacity in reservoirs. All of these effects may be observed in the Grand River itself and in its tributaries. Proposed resource improvements will do much to alleviate these problems.

Erosion from cropland in the Basin was found to average slightly more than 3 tons per acre per year. Erosion from pasture and forest land was much less. Conservation practices to be applied in the current and accelerated land treatment programs have the potential to reduce the current rates of erosion by 40 to 50 percent while maintaining or improving soil productivity.

The two multiple-purpose reservoirs and one single purpose reservoir in the watersheds proposed for early action will provide a total of 700 acre-feet of sediment storage. This storage capacity will be provided to maintain the full effectiveness of the reservoirs for the planned project life, and will also produce significant reductions in sediment loads downstream from the structures. Other single purpose reservoirs which may be developed within the potential watersheds would also be designed with sediment capacity, and would provide additional benefits.

Current criteria governing the installation of structural improvements are designed to minimize downstream movement of sediment during construction. Seeding of exposed channel banks, immediately following construction, selective spoil placement methods, and excavation of temporary sediment traps downstream from construction are some of the methods now being employed. Such practices will protect downstream areas

during the installation of needed improvements in upstream watersheds.

c. Fish and Wildlife In addition to measures which improve and protect the water, soil and crops, USDA programs will provide assistance in developing and preserving fish and wildlife resources. Agricultural lands and farmer cooperation are essential to the development, production, and harvest of fish and wildlife species. Land treatment programs will include such practices as field borders, hedgerow planting, wildlife habitat and wetland management, and fishpond management. Well managed forest lands and tree planting can improve the habitat for fish and wildlife by providing shelter and food, and by regulating climatic conditions.

The development of one single purpose reservoir within the potential watersheds will create 2,200 surface acres of water to be managed specifically for fish and wildlife purposes. The development of two multiple-purpose (flood prevention and recreation) reservoirs will provide 650 surface acres of water which will be managed in part for fish habitat. Establishment of vegetation in the recreation areas surrounding these sites will improve the wildlife habitat.

d. Quality of the Environment Improvements in water and related land resources are key elements in the effort to improve and maintain our environment. Land treatment measures to be applied in the nonstructural programs will control unsightly and costly erosion on the land itself. This in turn will reduce sedimentation of surface waters.

The establishment of recreation areas will provide a natural environment in which people may relax away from the complexities of urban life. The cities themselves will be improved through the conservation of forest land and the establishment of tree and plant cover in urban and suburban areas. Open areas of natural beauty will provide welcome visual contrasts to the maze of man-made structures. They will also help to dampen harsh city noises, and purify the air of pollutants while replenishing the atmosphere with oxygen.

2. ECONOMIC EFFECTS

a. Reduction in Damage Although the flood plains in the upstream watersheds of the Grand River Basin are generally narrow and not actively farmed, flood damage frequently does occur to the agricultural sector.

Most of the damage is of a combined nature emanating from inadequate existing channel depth or capacity and very flat topographic features.

Damage due to flooding and impaired drainage occurs primarily during the spring through inundation of crops and planting delays. Excessive soil moisture due to flooding and lack of adequate drainage outlets also occurs during summer and at harvest time. This condition increases cultivation and harvesting costs, adversely affects the quality of some crops, and depresses crop yields.

The 14 watershed projects proposed for completion by 1980 and an accompanying program of land treatment and management to control erosion and sediment problems will make significant reduction in damages from excess water on agricultural and forest land.

Average annual damages in the Basin from excess water due to flooding or inadequate channels amounts to $3,550,000. The proposed plan of development to be implemented in the next 10-15 years is estimated to reduce damages by $938,300 or 26 percent.

The 26 watershed projects proposed for completion following 1980 are intended to provide protection from flooding and inadequate drainage on an additional 62,000 acres. However, at this time most of the land within these projects is committed to uses other than crop production.

b. Improvements in Efficiencies Increased efficiency in the production of agricultural and forest commodities is possible through improved management and the combined effects of land treatment, flood prevention, agricultural drainage and irrigation. While additional water resource development is not required to meet future production objectives in the Basin, improvements upon existing resources can contribute to efficiency of production by reducing (1) crop losses, (2) the total cost of production, and (3) the acreage required to meet production objectives.

It should be noted that the improvements made through water resource and related land development tend to enhance the productive capabilities of the affected resources. In the development process, certain of these resources become more efficient in producing the Basin's output and, in turn, cause marginal land resources to shift out of production if additional output is not required. A portion of the overall

cost savings due to development may be passed on to the consumer in lower food prices, but a large share may be retained in the agricultural sector as improved incomes to those who can take advantage of the development opportunities. The total annual costs of meeting projected major crop production requirements without further resource developments are: 1980 - $36.3 million; 2000 - $50 million; and 2020 - $68.3 million (Table 50).

TABLE 50 - Projected annual cost of producing major crops without additional resource development and comparisons between full economic potential and 14 proposed projects, Grand River Basin, 1980, 2000, and 2020

Development level	1980	2000	2020
	(1,000 Dollars)		
Without additional resource development	36,318	50,047	68,296
With full economic development potential	33,653	48,019	66,588
With 14 proposed projects for Early Action	35,506	48,708	66,914
Savings in production costs with full economic development potential	2,665	2,028	1,708
Savings in production costs with 14 proposed projects	812	1,339	1,382

Source: Economic Research Service study of economic impacts associated with USDA proposed plan.

With resource development investment applied up to the level of full economic potential these production costs can be reduced to: 1980 - $33.7 million; 2000 - $48 million; and 2020 - $66.6 million. This represents a reduction of nearly 2.7, 2.0 and 1.7 million dollars in the respective time periods. The decline in potential costs efficiencies over time through water resource development reflects a relaxation of certain production constraints that were imposed on the analytical model in the more distant time periods. These constraints to full efficiency were imposed in the earlier time periods to simulate farmers tendencies to utilize the agricultural investments already committed

within the Grand River Basin. In the long run such barriers to the free flow of productive resources are less restrictive and other areas outside the Basin, notably the Thumb area of Michigan, are better able to compete for them. Consequently, such considerations have a negative influence on the development potentials within the Basin.

Not all the land that could be most efficiently developed in the Basin lies within feasible projects being proposed for installation by 1980. Annual cost reductions that appear possible on developed acreage within the early action program areas amount to $812 thousand - 1980, $1.3 million - 2000, and $1.4 million in 2020. As the evaluation period extends into the future, development within the fourteen proposed projects approaches the total economic potential for development.

Beyond 1980 the additional 26 projects will bring new land into production which must compete with available cropland that has a development potential. Estimating the potential cost reductions through these projects is hazardous. If the annual costs of production, land clearing, and development are by some chance less than production costs on marginal land, then these new acres will replace them in production and contribute to savings. But the displacement of developed acreage in the 14 Early Action projects is also possible. At this point the potential for additional development beyond the level proposed for 1980 appears to be limited.

c. Agricultural and Forest Production and Stabilization Projected demands for agricultural production in 1980 from the Basin call for 2.9 million tons of feed crops, 0.4 million tons of food crops, and 0.3 million tons of specialty crops. Feed crops consist of feed grains and roughages (corn, oats, barley, corn silage, pasture and hay). Food crops include wheat, soybeans, dry field beans, and potatoes while specialty crops are composed of a large variety of vegetable crops, tree fruits and berries. With no additional flood protection, irrigation, or drainage development, the 1980 production requirements can be met on 1,095,700 acres of cropland and pasture (Table 51). For the year 2000, demands for feed crops increase to 3.8 million tons, food crops to 0.8 million tons, and specialty crops to 0.4 million tons. All of which can

be produced on 1,392,500 acres of cropland and pasture without further resource development. Projected requirements for the year 2020 amount to 5.3 million tons of feed crop, 1 million tons of food crops, and 0.7 million tons of specialty crops. This production objective requires 1,589,200 acres of cropland and pasture in the absence of further resource development.

Projected demands for forest products in 1980 call for the cutting of 7.0 million cubic feet of timber from nearly 644,000 acres of forest land. Timber products generally include saw logs, veneer logs, minor industrial products such as piling and posts, and pulpwood. For the year 2000, forest product demand reaches 9.8 million cubic feet and by 2020, the volume is projected to be 12.8 million cubic feet. Forest land requirements to produce these products reach a high of 735,500 acres in 2000 and decline to about 699,000 acres by 2020 due to rising trends in growth rates.

Under the same production requirements, but considering the alternative of water resource development, the projected demands could be met on fewer, more intensively managed acres. This analysis indicates that under full economic development, the projected production requirements could be met on the following acreages of crop and pasture land: 1980 - 993,100 acres; 2000 - 1,326,600 acres; and 2020 - 1,463,300 acres. Associated with this irrigation and drainage development efficiency is the idling of marginal acres that are no longer required to meet anticipated food and fiber needs. These idled marginal acres could be converted to multiple forest and recreational use through revegetation. Intensified land management and treatment of forest land will permit expanded recreational opportunities and improved environmental quality while still meeting forest product requirements on available forest land acreage.

If only the development potential of the proposed fourteen projects is considered, less land would become idle while meeting identical production objectives. In 1980 acreage requirements would be reduced by 32,300 acres, 2000 - 28,800 acres, and in 2020 by 53,100 acres. Relatively more land is required in 2000 under both full development

TABLE 51 - Projected acreage required for producing major crops without additional resource development and comparisons between full economic potential and 14 proposed projects, Grand River Basin, 1980, 2000, and 2020

Development level	1980	2000	2020
	(1,000 acres)		
Acreage required without additional development	1,095.7	1,392.5	1,589.2
Acreage required with full economic development potential	993.1	1,326.6	1,463.3
Excess acreage with full economic development potential	102.6	65.9	125.9
Acreage required with development only in 14 proposed projects	1,063.4	1,363.7	1,536.1
Excess acreage with development only in 14 proposed projects	32.3	28.8	53.1

Source: Economic Research Service study of economic impacts associated with USDA proposed plan.

potential and development within the proposed projects, thus fewer acres are idled than in 1980 and 2020. This is largely due to relatively greater roughage requirements and smaller feed grain requirements than in the other two years. Feed grains are most likely to be grown on those soils that would respond more favorably to development than the soils in roughage production.

Additional development, associated with the 26 proposed projects after 1980, would contribute to the stock of idle acres as well. While the contribution might be significant it is doubtful whether it would exceed one quarter of the remaining potential. It is also conceivable that bringing new land into production might eliminate some existing potential on the current cropland base.

While it is true that idle acres for agricultural purposes are associated with resource development under a given level of agricultural production, it is also true that more acres are available for other uses. These same acres could be used to produce additional agricultural

commodities if other areas of the region or nation have higher production costs or are unable to meet their production targets. They could be used to expand from woodlots into an economically viable enterprise that would justify and also respond to intensive forest management. They may also be needed to replace acres withdrawn for non-agricultural uses at a rate faster than was originally assumed in this analysis.

Water resource development and associated land treatment programs, have the added advantage of reducing risk and uncertainty and stabilizing production. The vulnerability of agricultural production to climatic hazards is well recognized. All farmers face the problem of fluctuations in yields and production resulting from variations in rainfall as well as the other uncertainties of weather. Those resource owners with flood, drainage, or drought problems experience even greater risk and uncertainty than the average producer. The proposed fourteen projects will have a marked effect on reducing the risk and uncertainty associated with production on the 60,000 acres of cropland involved. As uncertainty is reduced, farmers can manage their resources more efficiently and provide a more stable agricultural economy. With reduction of the risks and uncertainties associated with flooding, drainage, and drought problems, production can be planned at the optimum level with the associated levels of purchased inputs. Losses will be cut to a minimum and production of a more profitable combination of crops with less yield fluctuation will result from better timing of operations. All of this will add greater stability to production levels within the Basin.

d. Income and Employment Stabilization of agricultural production on cropland and forest product output on forest land, both within the proposed projects and throughout the study area, may have varied effects on income and employment in the Basin. With stability of production comes stability of income, frequently at a higher average annual level. Stabilized income will encourage stabilized expenditures for factors of production and large machinery items rather than encouraging savings from periods of high income to cover anticipated periods of low income. Under normal conditions of moisture uncertainty, major machinery

purchases can only be made following a good year due to problems of income and credit availability. The credit position of farm operators whose income stream is continuous and fairly stable is far superior to one whose income stream reflects wide swings and in some years may even be negative.

Higher incomes and improved credit positions will tend to cause these farm operators to demand more service, purchase more productive inputs for the farm business and seek to expand their farming operations, all of which will have direct favorable income effects on the local business sector. In the process of expanding their farm operation these resource owners will acquire additional land resources, thereby displacing inefficient or marginal operators. The idling of marginal acres in connection with the proposed resource development program has already been discussed. It is an important fact that the marginal acres are not located in some specific area. They are interspersed throughout the Basin and occur to some degree on farms that will continue in production. Agricultural output displaced from these acres by the proposed program will be produced on fewer but more intensively managed acres with additional development. These operators will expand their purchased inputs. Over time they will invest more heavily in new labor saving technology in the form of larger more specialized machinery, pre-mixed feeds, and bulk handling. This along with the idled acreage will reduce the farm labor requirements more rapidly than would occur under a program of no further resource development.

It is rather difficult to evaluate the net effect of the proposed development program upon rural service communities within the Basin. On the one hand farmers on marginal units and unable to compete effectively have good opportunities in the Basin to enter part-time farming, at least in the short run. This allows them to take the first step in occupational migration and effectively removes their land from agricultural production in whole or in part since it contributes to total output at a low level. They are also able to convert the marginal cropland to forest enterprises and expand upon an already available but underutilized resource, the farm woodlot. Marginal operators and

part-time farmers do not apply advanced technology as rapidly as others in a more favorable competative position, preferring to substitute labor for capital, and thus purchase less production inputs. To the extent that they remain in the community, using their farms as rural residences or waiting for a return on improved forest land management while pursuing off-farm employment, they will bring added income to the community through non-farm purchases. Those that continue to farm on a reduced scale may also provide a ready market for used machinery from local dealers.

On the other hand shifts in the location of production will take place. Output that would have been produced on the marginal lands will relocate on the more productive acreage benefiting from water resource development. To the extent that local communities are dependent upon providing the inputs for this production and marketing the commodities produced, they will be disadvantaged. Of course other communities within the Basin would benefit from expanded activity in their area and in effect it would simply amount to an income transfer within the Basin.

Intensified management of forest land will improve the efficiency of existing small woodland ownerships. Where these areas can be expanded through the natural revegetation or conscious conversion of marginal crop and pasture land to productive forest land, otherwise disadvantaged areas will begin to benefit from the increasing sale of forest products. In time, the return to these communities from forest products may more than account for any loss due to a shifting of agricultural production out of the area. Over the long run, expanded production of forest products from the forest management and land treatment program will add significantly to local employment and income. The expanded volume of high quality timber in larger forest units will develop markets for timber products that would not have otherwise existed due to the inefficiencies of harvesting low quality-low yielding stands. Larger volume of higher quality timber will also command improved prices which will further add to the Basin economy.

Associated with the proposed 26 projects for long run consider-

ation is the conversion of some forest land to cropland. To maintain the projected level of forest product production in the Basin several additional steps will be required that will affect local economies in the long run. Some of the marginal cropland acreage idled through development will be required for an expanded tree planting program. Intensified management of existing forest land will be required to encourage growth of desired species to replace forest products that would have been forthcoming from the 26 project areas. This expanded forest management and land treatment program will add to local employment and will increase the market value of the residual stands. In the long run expanded production of forest products will take place in Basin areas other than previously anticipated prior to consideration of the development proposals.

e. Recreation Opportunities and Benefits The development of surface water reservoirs and related recreation facilities in watershed projects will be a very significant contribution of USDA programs toward meeting part of the outdoor recreation needs. The proposed developments will be located in the Lansing subarea which has extremely limited opportunities for water related outdoor recreation at the present time. They will provide annual benefits of $1,495,600.

These developments will provide only a portion of the needed recreation facilities. The other inventoried structure sites both within and outside potential watersheds offer opportunities for surface water development through other Federal, State, and local programs. Coordination of USDA programs with those of other agencies will lead to the optimum utilization of these basic recreation resources.

Additional benefits will be derived from private recreation facilities. These are difficult to quantify, but it is recognized that the private sector is an important part of the total outdoor recreation picture.

The largest portion of the hunting now takes place on private land within the Basin, usually without cost to the hunter. Wildlife habitat improvements through the land treatment program and land removed from cultivation through the Cropland Adjustment Program will help

insure the availability of game and hunting areas.

Private outdoor recreation enterprises provide needed facilities in many areas of the Basin, and are complementary to public developments. USDA programs which provide assistance for the establishment of these enterprises will help to meet the future recreation demand. The income derived from their operation will have an impact upon the local economy.

f. Water Supply Services The Basin has experienced substantial industrial and population growth and is projected to continue this trend due to its favorable location in Southcentral Michigan. Most of this growth has taken place in or near the three major population centers of Grand Rapids, Lansing, and Jackson. Each center has developed adequate water supply services and are expected to maintain and expand them to meet future demands. Large water using industries have also developed their own ground water sources of supply.

Of the new reported industrial development in Michigan during the decade 1957 to 1966, two-thirds were local expansions, one-sixth new starts, 10 percent came from somewhere else in the State, and 6 percent were from outside Michigan.* Future industrial growth will undoubtedly continue to favor locations with existing well developed facilities and a histroy of providing essential services. However, some new development is also expected to take place in rural areas where local communities have established satisfactory facilities.

No provision has been made for inclusion of municipal and industrial water storage in feasible small watershed projects in the Basin. These sites are located where adequate water systems are within reasonable distances to municipalities and industries. The USDA programs administered through the Farmers Home Administration are, however, ideally suited to assist local communities of 5,500 or less in developing their own water supply and sewage treatment facilities. FHA is

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*Manneman, Richard J., Employment Changes in Rural Michigan, Agricultural Economic Report No. 110, Michigan State University, September, 1958, page 19.

actively pursuing a program of planning, design, and financial assistance to local communities throughout Michigan.

It is anticipated that future rural farm and non-farm water supply requirements will be met primarily from ground water sources which are believed to be adequate for this purpose. However, in those locations where local water systems exist or are developed, this service will probably be extended where feasible to the rural population.

3. SOCIAL AND INSTITUTIONAL

Soil Conservation Districts will be primarily responsible for the local implementation of nonstructural and structural resource improvements. These subdivisions of the state government have been organized in each county of the Basin. They will assist landowners in planning and managing the land and water resources for the best long range use and development through the land treatment programs. Districts, while without powers of taxation, may serve as a sponsoring organization of watershed projects to assist in planning and to implement nonstructural phases of the project.

Drainage districts organized through the authority of the Michigan Drain Code are responsible for the installation and maintenance of drains and watercourses. They are empowered to levy and collect taxes for the installation of structural improvements. In most cases a drainage district will be sponsoring organization of watershed projects and will provide the local funds for sharing of installation costs. The drainage district will also be responsible for maintenance of the structural project measures for which it is a sponsor.

The Michigan Department of Natural Resource will cooperate in the planning and installation of recreation facilities in watershed projects, including cost-sharing. This agency may also have an interest in developing one or more of the inventoried structure sites for fish and wildlife or general recreation purposes, and will provide technical assistance for installation of forest land treatment measures.

Other units of government at the county or community level should participate in the planning and implementation of measures to accomplish needed resource improvements. Local participation and leadership will insure that the plans reflect the needs and interests of all citizens.

SECTION X

USDA WATER AND RELATED LAND RESOURCE PROJECTS AND MEASURES RECOMMENDED FOR EARLY ACTION

1. RECOMMENDATIONS FOR EARLY ACTION PROGRAM

It is recommended that an Early Action Program be carried out in the Grand River Basin, with the installation of all elements of the program being initiated prior to 1980.

In such a program, local organizations, upon their request, would be assisted in preparing and carrying out watershed work plans for the watershed designated in the Early Action Program.

Financial and other assistance would be provided to help install the works of improvement for furthering the conservation, development, and utilization of water and related land resources. Such assistance could be given on a basis comparable to that authorized for similar purposes under other Federal programs, with such modifications as necessary and appropriate in the public interest.

The recommendations for an Early Action Program are as follows:

a. The installation of structural works of improvement in 14 upstream watersheds. The costs are estimated to be $18,782,300, of which 61 percent will be assumed by the Federal government and 39 percent will be assumed by non-Federal interests.

b. A land treatment program in the upstream watersheds at an estimated cost of $7,763,500, including $6,771,800 for installation, and $991,700 for technical assistance;

c. A land treatment program on lands behind the proposed multiple-purpose structures to be implemented through existing programs at an accelerated rate of accomplishment. The estimated cost of this program is $18,572,100, including installation costs of $15,842,600 and technical assistance costs of $2,729,500;

d. A $1,400,000 technical assistance program to aid in soil and water conservation planning and environmental forestry to help improve the urban environment.

e. Accelerated soil surveys to complete the surveys within the Basin by 1980, at an estimated cost of $751,000.

2. DESCRIPTION OF EARLY ACTION PROGRAM

Studies made by USDA agencies and participation in coordinated studies with other agencies have shown that the following activities are feasible and desirable for implementation through an Early Action Program. The improvements and measures can be carried out through watershed projects in parts of the Basin, and by other local projects in remaining Basin areas. The improvements are necessary to begin to solve the most urgent problems in the Basin and will help more fully meet the estimated 1980 needs.

a. Watershed Projects Investigations showed that 14 of the 40 potential watershed sites (Plate 3, Addendum) were feasible projects on which to begin early action development. The projects would involve applying both structural measures as well as an accelerated land treatment program. No critical sediment-source areas have been identified in the 14 watershed sites as needing stabilization measures to be applied through the Early Action Program.

Table 42, page 155, summarizes the physical data of the 14 upstream areas having potential for development as part of the Early Action Program. Table 43, page 156, summarizes the economic data for the 14 projects. Table 46, page 160, summarizes the economic data concerning the accelerated land treatment measures to be applied in conjunction with the structural measures on these projects. The 14 Watershed Investigation Reports, providing greater physical and economic detail for each project are in the Addendum.

These watersheds may be developed if sponsored by qualified local groups. The scope and purpose of each watershed project will be dependent upon the desires and wishes of such sponsors. The installation of the planned works of improvement in the watersheds may be carried out under Federal construction contracts when requested by the local organizations.

b. Other Resource Improvements Part of the Early Action Program is an accelerated phase of the land treatment program behind multiple-purpose structures carried out through the soil conservation districts and the Michigan Department of Natural Resources in cooperation with the

Forest Service. As authorized under the PL-46, and Cooperative Forest Management programs, landowners received technical and financial assistance from the state and Federal government agencies to help them improve their natural resources. Under the accelerated phase, greater technical assistance will be provided, along with the possibility of expanded financial assistance through cost-sharing, conservation payments, and small loans. Table 48, page 165, summarizes the land treatment program for the lands behind multiple-purpose structures.

Environmental enhancement in urban and built-up areas is recommended as part of the Early Action Program. This is proposed as a joint State-Federal-local effort with the USDA assigned leadership in furnishing technical assistance for improving environmental conditions. Assistance in the non-forestry phases will be provided by the Soil Conservation Service through soil conservation districts under existing programs at an estimated cost of $800,000. The Forest Service through existing programs, will provide leadership for the forestry phase, which has an estimated cost of $600,000.

An accelerated program is recommended which will complete the soil survey throughout the Basin by 1980. This will be implemented through the National Cooperative Soil Survey.

3. SUMMARY OF EARLY ACTION PROGRAM PROPOSALS

An Early Action Program will be more effective in helping meet the Basin needs than just continuing the current resource improvement programs. The Early Action Program provides for accelerating the rate of improvements.

Both structural and nonstructural measures can be applied through watershed projects on the 14 areas having potential for development by 1980. An accelerated program of land treatment and management will also be applied to areas of the Basin outside the potential watersheds.

The Watershed phase of the Early Action Program includes 14 small watershed projects having a total area of 949.9 square miles. Structural improvements include 208 miles of channel improvement, two multiple-purpose flood prevention and recreation structures, and one single-purpose reservoir for fish and wildlife use. These measures will provide

flood prevention and improved drainage for 71,400 acres, and will create 2,850 acres of permanent surface water. Another nine reservoir sites with potential for purposes other than flood prevention were also identified within the 14 watershed areas. Average annual benefits from flood prevention, drainage, recreation, and fish and wildlife are estimated to be $2,723,600 compared to average annual costs of $1,267,100.

In terms of meeting land treatment needs for the entire Basin, the composite Early Action Program can help achieve them more quickly. Treatment deemed to be needed for cropland by 1980 would only be 19 percent completed through the current programs, but would be 68 percent completed with the Early Action Program. Pasture land treatment would be 10 percent completed compared to 42 percent. Forested land would be 4 percent completed compared to 14 percent. Treatment of miscellaneous land would be 3 percent versus 27 percent.

Flood damage can be markedly reduced in the Basin by installing the needed water control structures and land treatment measures. Reduction of damages in the potential watersheds along the Portage River, Upper Maple River, and Stony Creek drainages would exceed 80 percent of the present total. The Early Action Program would speed up their construction. Water management practices, notably for improved irrigation, drainage and domestic rural uses in the agricultural areas, affect the fulfillment of Basin needs. Through the Early Action Program, these practices can be applied more rapidly. Recreation areas, already in big demand, are an integral part of several of the 14 watershed projects. Their development under the Early Action Program will help ease the Basin problem of too little surface acreage for water-based recreation sports.

The conservation of forest land and the establishment of tree and plant cover in urban and suburban areas will provide a more desirable environment with open areas of natural beauty. Retaining the maximum amount of forest and plant cover on areas being developed for residential, commercial, or industrial use will help control erosion and sedimentation, and lead to general environmental enhancement.

The availability of detailed soils information will result in improved land use planning which will help eliminate costly problems

associated with improper site selection.

The total estimated cost of the Early Action Program is $47,268,900, with $28,486,600 for land treatment, $8,432,900 for flood prevention, $5,525,500 for drainage, $4,668,000 for recreation, and $155,900 for fish and wildlife. A summary of the benefits and costs is found on Table 52, page 194. Table 53 presents cost-sharing for the Early Action Program.

TABLE 52 - SUMMARY OF COSTS AND BENEFITS OF EARLY ACTION PROGRAM

GRAND RIVER BASIN, MICHIGAN

Watershed Name	Water-shed Area (sq. miles)	Work of Improvement: Channel Improve-ment (miles)	Work of Improvement: Structure Sites (number)	Total 5/ Install-ation Cost (dollars)	Average Annual: Instal-lation Cost 6/ (dollars)	Average Annual: Benefits 7/ (dollars)	Benefit Cost Ratio
Twin Lakes Drain	5.4	5.4		90,700	5,672	6,201	1.09:1
Freeman Marsh Drain	8.0	7.2		120,000	7,486	8,084	1.08:1
Huntoon Lake	11.6	6.4		110,600	6,861	8,585	1.25:1
Perry Creek	10.4	5.3		105,300	6,537	10,000	1.53:1
Bly Lake	11.7	8.8		148,700	9,238	11,778	1.27:1
Eaton Rapids	13.6	8.3		140,900	8,759	10,065	1.15:1
Upper Columbia Creek	18.3	7.6		119,300	7,669	11,739	1.53:1
Portage River	185.8	21.5	171 4/	3,892,250 8/	228,832	247,810	1.08:1
Prairie Creek	46.0	8.4		230,500	14,482	16,201	1.12:1
Libhart Creek	17.1	8.4		128,100	8,342	10,325	1.24:1
Upper Maple River 1/	312.0	54.2 2/	109-110 3/	11,287,400	817,059	2,190,700	2.70:1
Hayworth Creek	93.5	14.0		531,700	32,290	51,150	1.58:1
Stony Creek	178.1	42.1		801,200	53,510	63,514	1.19:1
Rogue River	37.9	10.6		1,075,650	60,348	77,500	1.28:1
TOTAL	949.4	208.2		18,782,300	1,267,085	2,723,652	2.51:1

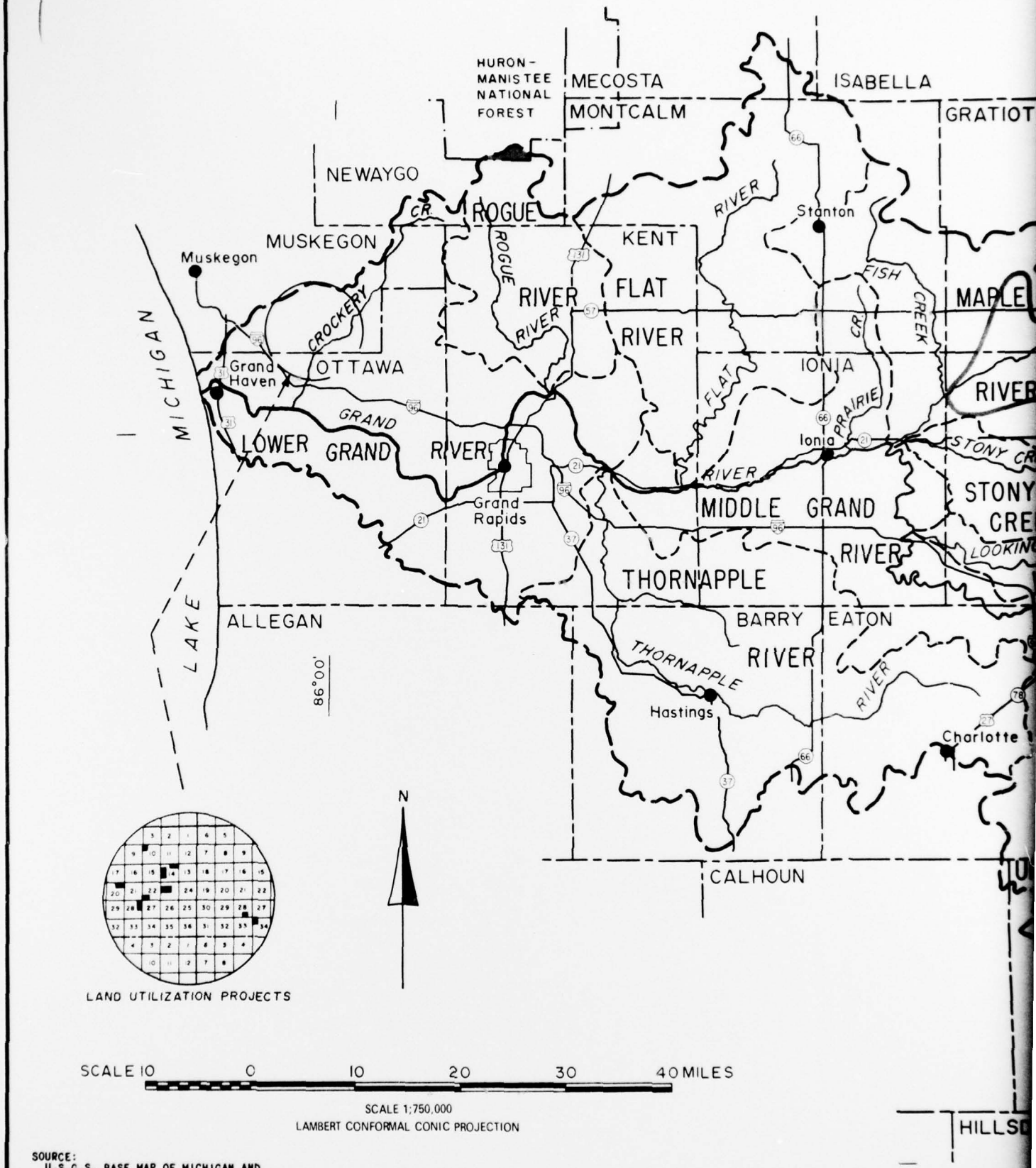
1/ Data from PL-566 work plan, both East and West, July 1969.
2/ In addition to channel improvement, there are two multiple-purpose structures, 14.4 miles of dike construction, and four drainage pumping stations.
3/ Multiple-purpose structures, flood prevention and recreation.
4/ Single-purpose, fish and wildlife structure.
5/ Price base - 1967.
6/ Amortized at 4 7/8 percent interest over a 50-year period, includes O & M cost.
7/ Price base - adjusted normalized prices.
8/ Includes $155,900 installation cost for structure No. 171, Fish and Wildlife.

TABLE 53 - COST SHARING OF EARLY ACTION PROGRAM

GRAND RIVER BASIN, MICHIGAN

Planned Improvement	Total Installation Cost (Dollars)	Cost Sharing	
		Federal (Dollars)	Non-Federal (Dollars)
Land Treatment - Accelerated			
1. On 14 Upstream Watersheds			
A. Installation	6,771,800		6,771,800 1/
B. Technical assistance	991,700	962,300	29,400
2. Behind Multiple-Purpose Structures			
A. Installation	15,842,600		15,842,600
B. Technical assistance	2,729,500	2,576,600	152,900
3. Environmental Enhancement in Urban and Built-up Areas			
Technical assistance	1,400,000	1,400,000	
4. Accelerated Soil Survey	751,000	751,000	
Total Land Treatment	28,486,600	5,689,900	22,796,700
Structural Measures			
1. Flood Prevention - 208.2 miles of multiple-purpose channel improvement, (Flood Prevention and Drainage), 14.4 miles of dike construction, including 4 pumping stations, and allocated cost of structure site 109-110 to flood prevention, Maple River Watershed	8,432,900	7,298,800	1,134,100
2. Agricultural water management (Drainage) - 208.2 miles of multiple-purpose channel (Flood Prevention and Drainage)	5,525,500	2,543,900	2,981,600
3. Recreation - Maple River Watershed, including allocated cost of structures sites No. 109-110	4,668,000	1,526,000	3,142,000
4. Fish and Wildlife - Structure site No. 171. Portage River Watershed	155,900	46,800	109,100
Total Structural Measures	18,782,300	11,415,500	7,366,800
GRAND TOTAL FOR BASIN	47,268,900	17,105,400	30,163,500

1/ Does not reflect Federal cost-sharing assistance which may be available for installation of conservation measures through various programs.



SOURCE:
U.S.G.S. BASE MAP OF MICHIGAN AND
DATA SUBMITTED BY FIELD TECHNICIANS

GRAND R

LAND RESOURCE
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NATIONAL FOREST
COUNTY BOUNDARY
MAJOR HIGHWAY
DRAINAGE - - -
COUNTY SEAT - -
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MAP OF
GRAND RIVER BASIN–MICHIGAN

LEGEND

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LAND UTILIZATION PROJECTS - - - - - - - - - - - -
NATIONAL FOREST - - - - - - - - - - - - - - -
COUNTY BOUNDARY - - - - - - - - - - - - - - -
MAJOR HIGHWAY - - - - - - - - - - - - - - - -
DRAINAGE - - - - - - - - - - - - - - - - - - -
COUNTY SEAT - - - - - - - - - - - - - - - - - -
STATE CAPITOL - - - - - - - - - - - - - - - - -
BASIN BOUNDARY - - - - - - - - - - - - - - -
SUB-BASIN BOUNDARY - - - - - - - - - - - - -
SUB-BASIN NAME - - - - - - - - - - - ROGUE RIVER

(Land Resource Areas described on page 15)

BORDER REV.
12 22 69

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PLATE 1

SCALE 10 0 10 20 30 40 MILES

SCALE 1/750,000

LAMBERT CONFORMAL CONIC PROJECTION

SOURCE:
U.S.G.S. BASE MAP OF MICHIGAN AND DATA
SUBMITTED BY SCS RIVER BASIN STAFF

2

SOIL AS
GRAND RIVER

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2 ——
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6 ——
7 ——
Floodplain ——
Drainage ——
Basin Boundary ——

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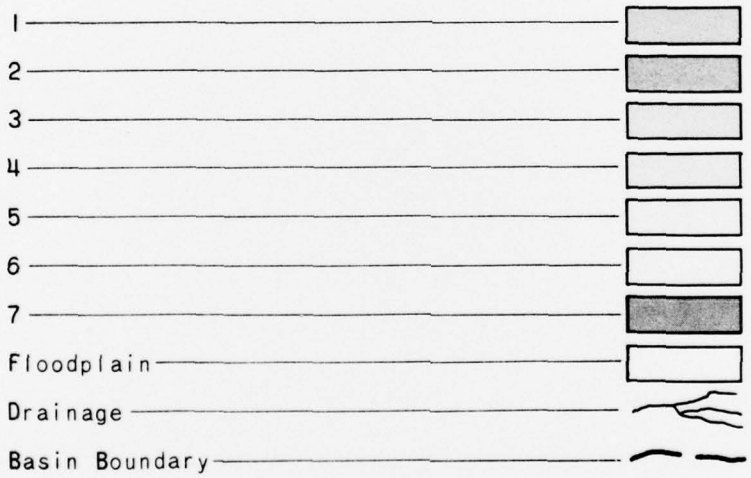
SOIL ASSOCIATIONS
GRAND RIVER BASIN–MICHIGAN

LEGEND



(For more information see Tables 4 and 5)

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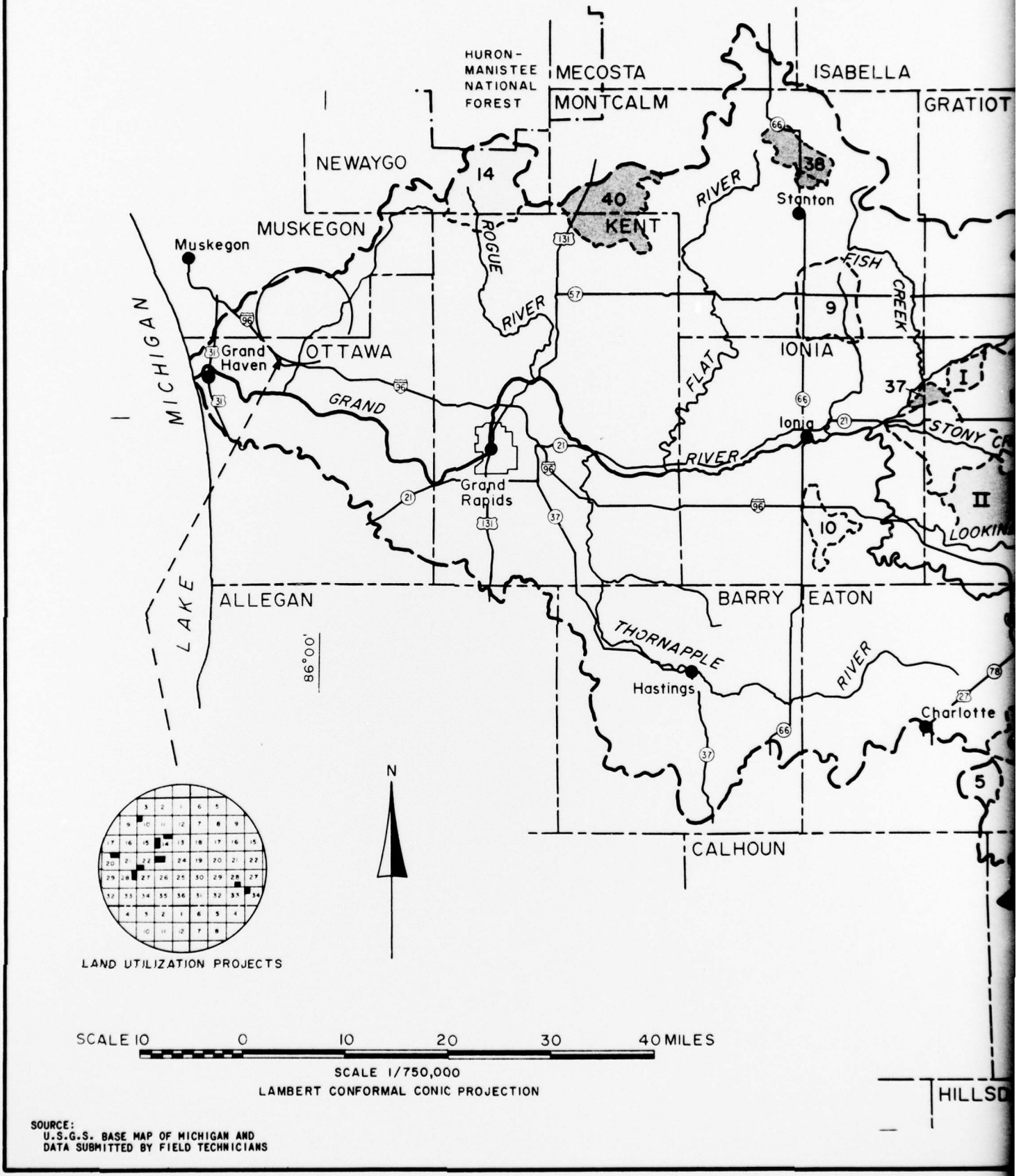
PLATE 2



SOURCE:
U.S.G.S. BASE MAP OF MICHIGAN AND
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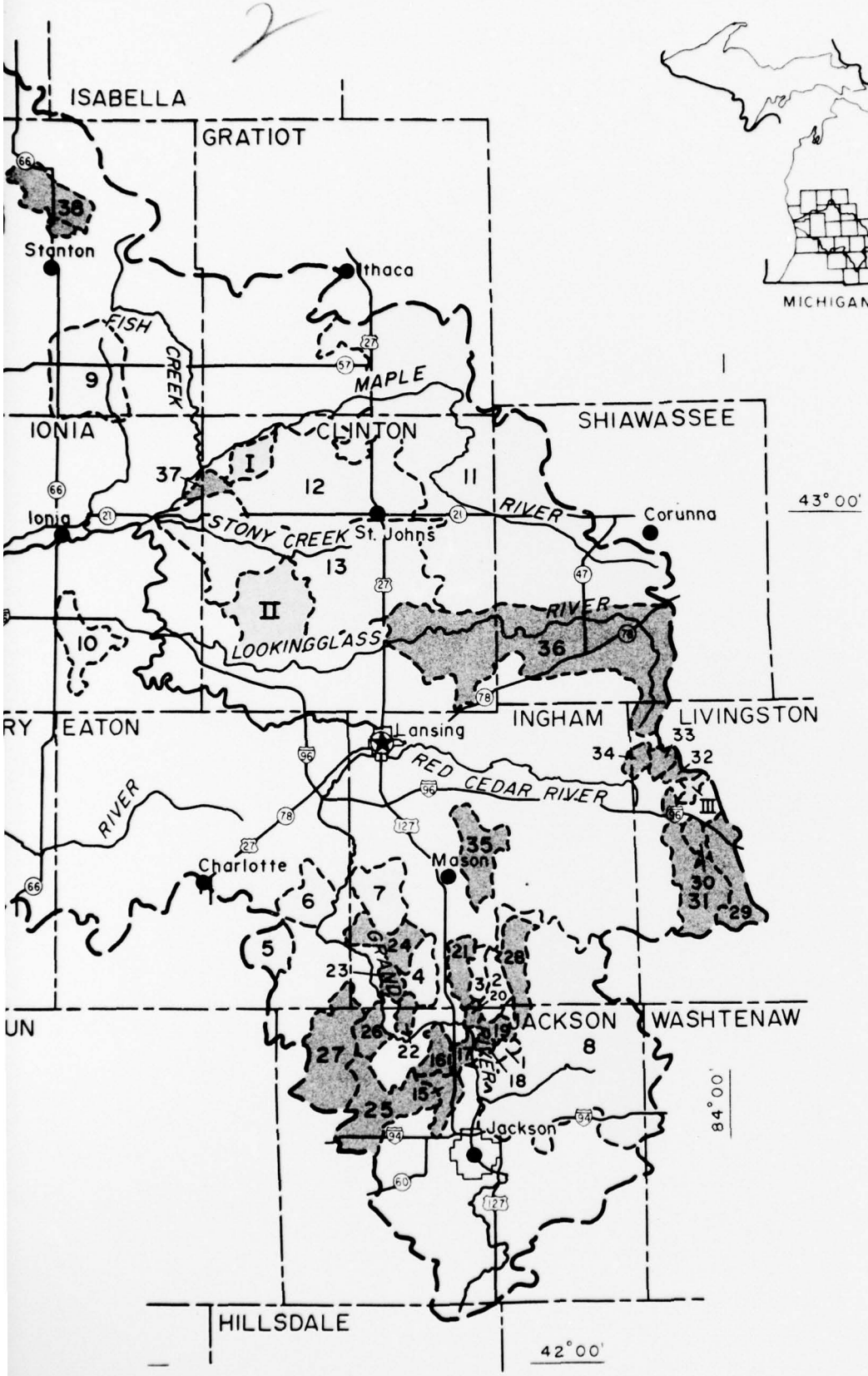

WATERS
WITH POTENTIAL
GRAND RIVER

AUTHORIZED WATERSHE
PROJECTS

I CATLIN-WATERS, REYNOLDS-
SESSION
II MUSKRAT CREEK
III FOWLERVILLE

POTENTIAL WATERSHEDS
10-15 YEARS

1 TWIN LAKES DRAIN
2 FREEMAN MARSH DRAIN
3 HUNTOON LAKE
4 PERRY CREEK
5 BLY LAKE
6 EATON RAPIDS
7 UPPER COLUMBIA CREEK
8 PORTAGE RIVER
9 PRAIRIE
10 LIBHART CREEK
11 UPPER MAPLE RIVER
12 HAYWORTH CREEK
13 STONY CREEK
14 ROGUE RIVER

LAND UTILIZATION PROJECTS - -
NATIONAL FOREST BOUNDARY - -
COUNTY BOUNDARY - - - - - - -
MAJOR HIGHWAY - - - - - - - -
DRAINAGE - - - - - - - - - -
COUNTY SEAT - - - - - - - - -
STATE CAPITOL - - - - - - - -
BASIN BOUNDARY - - - - - - -

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3

WATERSHED AREAS WITH POTENTIAL FOR DEVELOPMENT GRAND RIVER BASIN–MICHIGAN

LEGEND

AUTHORIZED WATERSHED PROJECTS

- I CATLIN-WATERS, REYNOLDS-SESSION
- II MUSKRAT CREEK
- III FOWLERVILLE

FUTURE POTENTIAL WATERSHEDS

- 15 SNYDER AND WHEELER DRAIN
- 16 RIVES JUNCTION
- 17 STATE
- 18 BERRY LAKE
- 19 PLEASANT LAKE
- 20 WHITNEY DRAIN
- 21 LESLIE
- 22 DARLING CHRISTIE DRAIN
- 23 LANES LAKE
- 24 WILLOW CREEK
- 25 SANDSTONE CREEK
- 26 TOMPKINS
- 27 SPRING BROOK
- 28 BATEESE CREEK
- 29 UPPER CEDAR RIVER
- 30 WINEGAR
- 31 MIDDLE CEDAR RIVER
- 32 RANDAL
- 33 GRANT
- 34 BROWN
- 35 MUD CREEK
- 36 LOOKINGGLASS RIVER
- 37 PEWAMO
- 38 PENNY CREEK
- 39 HEMMINGWAY LAKE
- 40 BLACK CREEK (Montcalm & Kent)

POTENTIAL WATERSHEDS 10-15 YEARS

- 1 TWIN LAKES DRAIN
- 2 FREEMAN MARSH DRAIN
- 3 HUNTOON LAKE
- 4 PERRY CREEK
- 5 BLY LAKE
- 6 EATON RAPIDS
- 7 UPPER COLUMBIA CREEK
- 8 PORTAGE RIVER
- 9 PRAIRIE
- 10 LIBHART CREEK
- 11 UPPER MAPLE RIVER
- 12 HAYWORTH CREEK
- 13 STONY CREEK
- 14 ROGUE RIVER

LAND UTILIZATION PROJECTS

NATIONAL FOREST BOUNDARY

COUNTY BOUNDARY

MAJOR HIGHWAY

DRAINAGE

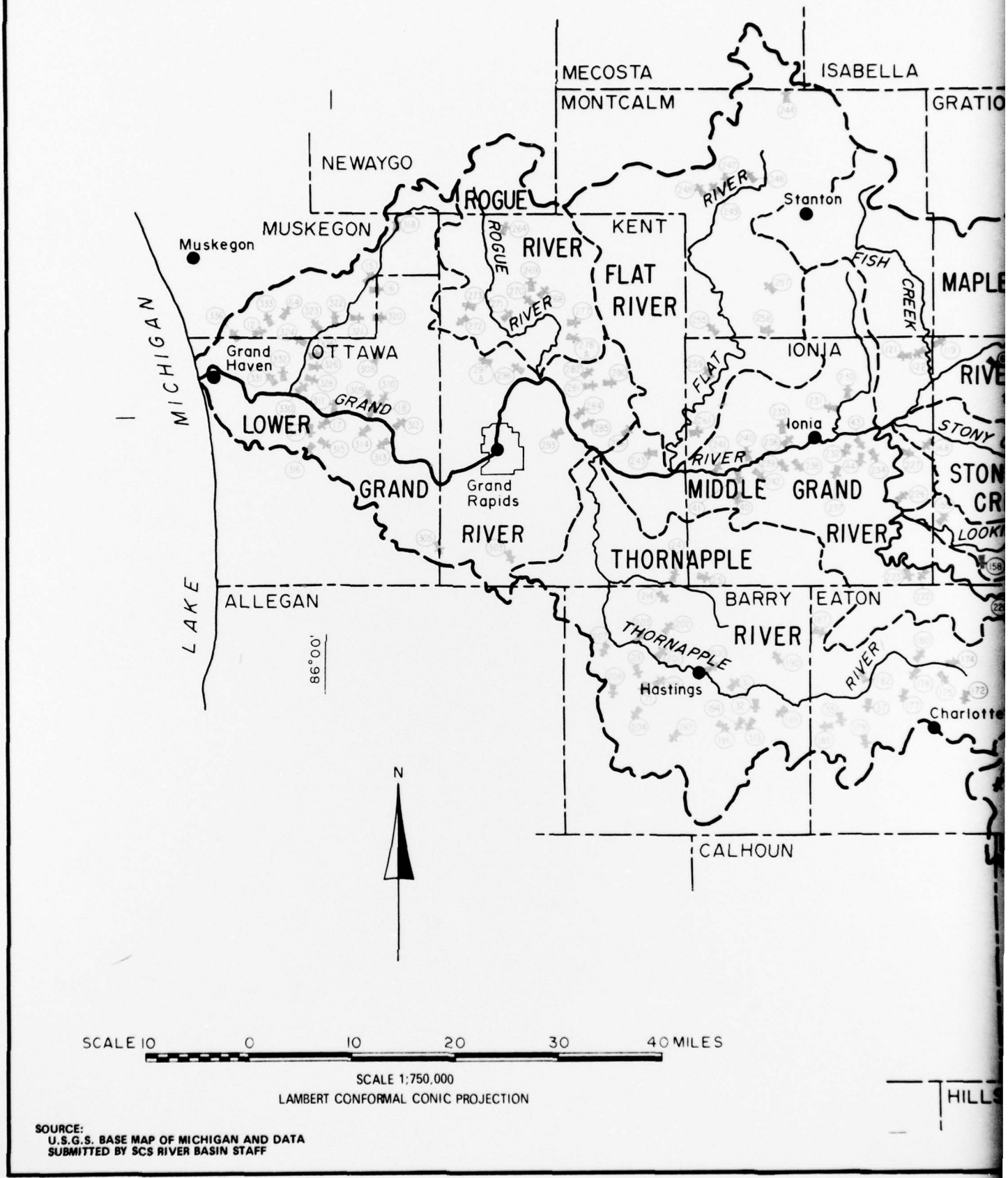
COUNTY SEAT

STATE CAPITOL

BASIN BOUNDARY

REV. 12/22/69
5,R-23734

PLATE 3



SOURCE:
U.S.G.S. BASE MAP OF MICHIGAN AND DATA
SUBMITTED BY SCS RIVER BASIN STAFF

POTENTIAL RE
GRAND RIVER

LEGEND

RESERVOIR SITE AND NUMBER - - -
COUNTY BOUNDARY - - - - - - - -
DRAINAGE - - - - - - - - - - - -
COUNTY SEAT - - - - - - - - - -
STATE CAPITOL - - - - - - - - -
BASIN BOUNDARY - - - - - - - -
SUB-BASIN BOUNDARY - - - - - -

3

POTENTIAL RESERVOIR SITES
GRAND RIVER BASIN–MICHIGAN

LEGEND

RESERVOIR SITE AND NUMBER

COUNTY BOUNDARY

DRAINAGE

COUNTY SEAT

STATE CAPITOL

BASIN BOUNDARY

SUB-BASIN BOUNDARY

BORDER REV.
12 22 69

5,R-23735

PLATE 4